VOL. 46 JUNE, 1931 No. 2

JOURNAL

OF THE

Elisha Mitchell Scientific Society

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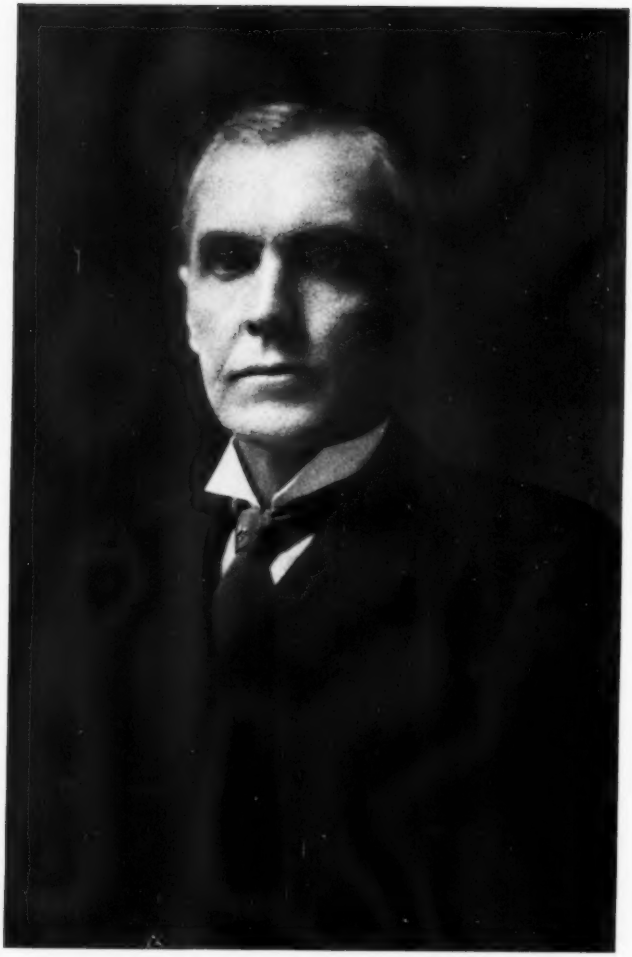
JOURNAL OF THE ELISHA MITCHELL SCIENTIFIC SOCIETY—Semi-annual. Price $3.00 per year; single numbers, $1.50. Direct all correspondence to the Permanent Secretary, at the University of North Carolina, Chapel Hill, N. C.

In addition to original papers on scientific subjects, this Journal publishes the Proceedings of the Elisha Mitchell Scientific Society, and the Proceedings of the North Carolina Academy of Science, as well as abstracts of papers on scientific subjects published elsewhere by members of the faculty of the University of North Carolina.

PUBLISHED FOR THE SOCIETY
BY THE
UNIVERSITY OF NORTH CAROLINA PRESS

Made in United States of America



WILLIAM CAIN
1847–1930

JOURNAL

OF THE

Elisha Mitchell Scientific Society

Volume 46 June, 1931 No. 2

WILLIAM CAIN

William Cain was born in Hillsboro, N. C., May 14th, 1847. After studying in a private school in Hillsboro and at the Hillsboro Military Academy he was graduated in 1866 from the North Carolina Military and Polytechnic Institute. He engaged in the practice of railroad engineering until 1874 at which time he accepted a Professorship of Mathematics at the South Carolina Military Academy. In 1888 he came to the University of North Carolina as Professor of Mathematics, which position he held until his retirement in 1920. From then until the time of his death on December 6, 1930, he was actively engaged in engineering research and in constructive criticism of the work of his colleagues in this country and abroad.

As a youth he was too young to serve actively in the army of the Confederacy, but his excellent training in military affairs made him invaluable as a trainer of troops. As a teacher he was patient, painstaking and inspirational. He was never married. A great lover of hunting and of music, he spent most of his leisure moments with his gun or with his violin. He was a writer of numerous texts on mathematics and engineering. To the end of his illustrious career his active mind was engaged in the formulation of important theories in engineering, particularly in earth pressure, arches, dams and retaining walls.

Always a gentleman, with splendid dignity softened by unusual grace, he was a dependable friend, a splendid raconteur. He was keenly appreciative of humor, and ever kindly disposed to all. He combined the fineness of his generation with the alertness of modern times. The

remembrance of him in his eighties sitting night after night alone carrying the activity of youth to the confines of age will always prove an inspiration to all who knew him.

That honors should come to such as he was inevitable. He was a member of the American Mathematical Society, the only native North Carolinian ever to be a director of the American Society of Civil Engineers, a fellow of the American Association for the Advancement of Science, a member of the Elisha Mitchell Scientific Society, a member of the North Carolina Academy of Science. In 1923 the American Society of Civil Engineers presented him with the Croes medal for his paper "The Circular Arch under Normal Loads." He was one of the original five Kenan professors at the University of North Carolina. In 1916 the University of South Carolina conferred on him the honorary degree of Doctor of Laws. In 1920 the University of North Carolina conferred on him the degree of Doctor of Science.

The Mitchell Society to which he contributed many of his important papers and the Academy of which he was a member almost from its founding suffer in his going an irreparable loss.

J. W. LASLEY, JR.,
THORNDIKE SAVILLE,
W. W. RANKIN,
Committee from the North Carolina Academy of Science

PROCEEDINGS OF THE ELISHA MITCHELL SCIENTIFIC SOCIETY

OCTOBER 8, 1929, TO MAY 13, 1930

314TH MEETING, OCTOBER 8, 1929

W. DEB. MACNIDER: *Regeneration of the Kidney and its Bearing on Kidney Function.* (Illustrated).

A. S. WHEELER: *Further Para-Cymene Studies.*

Recent researches which were completed in the organic laboratory of the University of North Carolina were concerned with (1) para-cymyl-4-semicarbazide (with J. G. Park); (2) para-bromophenyl-4-semicarbazide; and (3) para-cymylhydrazine-2 (with C. L. Thomas).

(1) Para-cymyl-4-semicarbazide was prepared as follows. Amino-cymene in glacial acetic acid was treated with potassium cyanate. The cymylurea thus obtained was heated with hydrazine hydrate for 30 hours. Eleven semicarbazones were prepared by treating the semicarbazide with the following ketones: acetone, methylethyl ketone, alpha-gamma-dichloroacetone, mesityl oxide, acetoacetic ester, cyclo-hexanone, camphor, carvone, benzophenone, acetophenone and benzoin.

(2) Cymylhydrazine was prepared by diazotizing aminocymene and reducing the product with sodium sulfite. Three salts, the hydro-bromide, sulfate and picrate, were made. Also the cymylhydrazones of cinnamylaldehyde, salicylaldehyde and benzophenone. Also cymyl-l-semicarbazide, cymyl-l-thiosemicarbazide and p-nitrobenzoyl-p-cymyl-hydrazine.

(3) Para-bromophenyl-4-semicarbazide was prepared by treating p-bromophenylurea with hydrazine hydrate. The semicarbazones of acetone, acetophenone, benzophenone, alpha-gamma-dichloroacetone and methylethyl ketone were prepared.

315TH MEETING, NOVEMBER 12, 1929

E. K. PLYLER: *Study of Molecular Structure from Band Spectra.*

An experimental study has been made of the infra-red absorption spectra of some organic nitrates and alcohols. There were found many

similarities between the two spectra and that the organic nitrates did not have any of the bands which were found in the inorganic nitrates. This difference was probably due to the nitrate ion in the organic compounds being broken up into other groups and that OH groups were formed causing the alcohols and the organic nitrates to have many like absorption bands.

J. F. DASHIELL: *Some Psychological Effects of Insulin.*

A diabetic patient completely dependent upon insulin was tested at intervals through a normal day, and with these results were compared tests made during the condition (hyperglycemia) of underdosage of insulin, and during the condition (hypoglycemia) of overdosage of insulin (i.e., not balanced with food). Four tests were used: strength (on Smedley dynamometer); color naming; cumulative adding (orally adding 2, then 3, then 4, then 5, then 2, etc.); and serial discrimination (telegraph keys pressed according to number appearing in Ranschburg exposure apparatus, keys wired through Ranschburg and electric recording markers). (1) Deterioration was observed in all four functions during both abnormal physiological conditions. (2) In hypoglycemia the deterioration was both very rapid and very profound. (3) It probably did not parallel changes in B-S level at the same rate of progress. (4) The character of the impairments suggests explanation in terms of changes in the higher nervous centers. (5) Need of further work is indicated.

316TH MEETING, DECEMBER 10, 1929

T. F. HICKERSON: *A Design of Rigid Frame.*

COLLIER COBB: *Human Habitations as a Response to Environment.* (Lantern).

317TH MEETING, JANUARY 14, 1930

W. F. PROUTY: *Relation of Geological Structures to Marble Quarrying.*

There are several distinct structural types of calcite marble deposits in eastern United States. Each of these has its favorable method of working and its own peculiar structural problems. These types can be roughly classified under three heads, according to the amount and character of metamorphism which they have undergone.

The Georgia type represents conditions where metamorphism has been intense. The crystals are large and generally twinned, the folding

has been excessive, and drag-folding at a maximum. Here the old lines of unsoundness have been largely healed by flow and crystallization of the limestone. Bedding planes are inconspicuous and color banding, due to crumpling and drag-folding, largely controls quarry methods. Under such conditions the quarries are operated with level floors and vertical channelling. Color conditions in all marble correspond largely to bedding conditions. Some beds are colored very differently from others, so that the quarry problem in this type largely resolves itself into the determination of the position of certain objectionable or favorable color areas in the stone. A knowledge of the structure may enable one to take out blocks with the minimum of objectionable color mingling.

In areas of intermediate metamorphism, where folding is less intense and faulting and shearing more prevalent, as in Alabama, there are a number of vexing problems to be solved in profitably extracting the marble. The bedding and shearing planes occurring at a considerable angle to the horizontal. These conditions exclude the level-floor method of quarrying and necessitate the saw tooth method of marble extraction. In this type of deposit, to get the best results out of quarrying, attention must be paid to the bedding, the various joint and fracture systems, and to the color differences. In some localities, to get the highest percentage of sound blocks, the direction of channelling is necessarily taken obliquely to the strike and dip. In one well-known quarry this shift from channelling parallel with dip and strike to an oblique direction increased the production of sound marble by about 75 per cent. In marble areas of this type success or failure in marble quarrying is largely dependent upon conformity or nonconformity with geological structures.

A third type of marble deposit is represented by the East Tennessee marble belt where folding, faulting, and shear are not important and where compressional and tensional jointing are the ruling factors in unsoundness. In this region compressional and higher temperature metamorphosis are at a minimum, and lower temperature crystallization through solution has played the larger rôle. Bedding in such a region is usually distinct, though usually modified by differential solution along the stylolite or original bedding planes. In this region there is the closest possible relation between quarrying and fold structure. There is probably not a single quarry in this section of the country that has found suitable quarry conditions prevailing over fairly sharp anticlinal folds. The most successful quarry operations have taken place in relatively broad synclinal areas.

J. M. VALENTINE: *The Olfactory Sense in Beetles.*

There is considerable disagreement among entomological physiologists regarding the location and morphology of olfactory organs in insects, differences in experimental technique being largely responsible for the conflicting results.

The purpose of this investigation is to produce evidence which will help to settle the question in so far as a single insect species is concerned. The common mealworm beetle, *Tenebrio molitor* (Linn.), was selected because of its hardiness and the ease with which it can be bred.

Experiments in which the odor of food and the sexual odor of the female were used to stimulate beetles deprived of one or both antennae or the distal segments of this appendage, indicate that the olfactory organs are borne by the antennae and principally by their four terminal segments.

A distinct peg-organ with a probably permeable cuticle was discovered in large numbers occupying areas on the antennae where the olfactory organs were experimentally located.

In experiments in which an essential oil was employed as the stimulant, the reactions of insects operated as above clearly show the irritating effect of the oil on nerve-endings not normally operative in the perception of odors natural to the organism.

Doubt is therefore thrown on the validity of the conclusions drawn by those workers who have used essential oils to determine the location of olfactory organs in insects and who are thus led to the opinion that these organs are distributed at various points on the legs, wings and body.

318TH MEETING, FEBRUARY 11, 1930

F. P. BROOKS: *The Vitamin D Content of Shrimp Oil.*

The product resulting from the extraction with ether of the dried waste of "shrimp" was used in rat feeding experiments on animals rendered rachitic by Steenback's diet No. 2965. Various amounts of the extract were fed for varying lengths of time and the animals examined for effect. The bones and blood were analyzed for Ca and P and sections of the tibias were prepared and examined for evidence of McCallum's line test.

The results of several typical experiments presented in charts and graphs and photographs of the bone sections shown on the screen demonstrated that the shrimp preparation had a definite curative effect on rachitic animals but to a less extent than a good grade of cod liver

oil. The later experiments appeared to show a deterioration in the vitamin content of the material.

Conclusions: Shrimp oil, when prepared with precautions designed to protect vitamin content will probably show a vitamin D content not much less than that of cod liver oil. This is to be checked by further experiments on a fresh and more carefully prepared preparation.

W. C. GEORGE: *The Unit of Life.*

The sharp distinctions that once existed between the physical sciences and the biological sciences have disappeared. The boundaries of the various natural sciences have enlarged until they overlap and we find these sciences occupying a common domain. Furthermore, the distinctions between animals and inanimate substances have become vague. Those phenomena that we have heretofore called fundamental vital phenomena (motility, sensitivity, metabolism, growth, and reproduction) have proved upon critical analysis to be unreliable criteria for distinguishing living substance from non-living substance. Our traditional concepts that limit the boundaries of life by the surfaces of what we call organisms, are inadequate. Forces and substances external to cell membranes seem quite as much a part of the life process as the forces and substances within the cell. The universe itself may be looked upon as the ultimate organism and life as being co-extensive with time and space.

319TH MEETING, MARCH 11, 1930

W. R. BERRYHILL: *The Effect of the Eating of Liver on Pernicious Anemia.*

H. D. CROCKFORD: *Some Thermodynamic Studies of the Nitro-Toluenes.*

The work on the temperature-composition diagrams of the binary systems of the nitro-toluenes with another component has been extended to benzoic acid. An apparatus has been developed which gives results of a much higher order of accuracy than those obtained heretofore. This apparatus can also be used for the photographing of cooling curves.

The systems with benzoic acid all prove to be simple ones showing no indication of compound formation.

320TH MEETING, APRIL 8, 1930

J. W. LASLEY, JR.: *Some Conics Associated with a Plane Curve.*

This study concerned itself with a construction for the members of the family of penosculating parabolas and of the family of penosculat-

ing equilateral hyperbolas associated with a curve at a point of it. Through the lines of the pencil on the point of the given curve a one to one correspondence was set up between the members of these two families.

C. M. CHILD, Duke University: *Some Recent Experiments in Transplantation.*

321ST MEETING, MAY 13, 1930

OTTO STUHLMAN, JR.: *The Motion and Bursting of Bubbles Rising through Liquids.*

F. K. CAMERON: *Absorption of Sulphur Dioxide by Calcium Phosphates.* See abstract in this Journal, **46**: 26. 1930.

R. W. BOST, *Sect.*

FLORA OF THE TRYON REGION

An Annotated List of the Plants Growing Spontaneously in Polk County, North Carolina, and Adjacent Parts of South Carolina, in Greenville and Spartanburg Counties

Part VI. Daisy Family (Compositae). List of New Names Published. Errata. Summary

By Donald Culross Peattie

Family 123. COMPOSITAE (Daisy Family)

925. **Vernonia glauca** (L.) Willd. (Ironweed)
Serratula glauca L.
Vernonia noveboracensis var. *latifolia* Gray

Frequent in open meadows on the piedmont, summer and autumn. Specimen: Columbus, Nov. 1926 (PT. no. 2359).

926. **Vernonia tomentosa** (Walt.) Ell. (Ironweed)
Chrysocoma tomentosa Walt.
Vernonia noveboracensis var. *tomentosa* Britton
Vernonia Rugeliana Shuttlw.

Frequent on the Porter loams, in the mountains. Specimens: White Oak Mt., Aug. 18, 1899 (Towns.). White Oak Mt., 2000 ft., July 21, 1921 (PT. no. 1010).

927. **Elephantopus carolinianus** Willd. (Elephant's-foot)

Common in deciduous woods and meadows of the foothill region. Specimens: Tryon, Aug. 3, 1897 (Towns.). Shady glens, Tryon, Aug. 23, 1921 (PT nos. 1344, 1355). Clearings, Tryon, Sept. 15, 1926 (Hunnew. no. 9950).

928. **Elephantopus tomentosus** L. (Elephant's-foot)

Common in woods and fields, piedmont region. Specimens: Tryon, 1897 (Towns.). Tryon, Aug. 9, 1921 (PT. nos. 1137).

929. **Eupatorium purpureum** L. (Joe-Pye Weed)
Eupatorium verticillatum Lam.
Eupatorium maculatum Wood, not L.
Eupatorium purpureum var. *maculatum* Darl.

Very common attractive flower of the summer and autumn woods, found throughout. Specimens: Fox Mt., July 27, 1897 (Towns.). Tryon, July 19, 1921 (this specimen almost white!) and Aug. 11, 1921 (PT. nos. 992, 1155).

930. **Eupatorium maculatum** L. (Joe-Pye Weed)
Eupatorium amoenum Pursh
Eupatorium purpureum of Britton and Brown, "Flora," ed. 2.
Eupatorium purpureum var. *amoenum* of Gray's "Manual" ed. 7.

Frequent in woods throughout. Specimen: Tryon, Aug. 12, 1921 (PT. no. 1205).

931. **Eupatorium album** L. (Thoroughwort)
Eupatorium glandulosum Michx.

Occasional in barren pine woods. Specimen: Spring Mt. Park, Sept. 18, 1897 (Towns.). Miss Wright reports it from Tryon.

932. **Eupatorium hyssopifolium** L. (Thoroughwort)
Eupatorium linearifolium Walt.
Uncasia hyssopifolia Greene

Occasional, in sterile woods and sandy fields. Specimen: Columbus, Sept. 6, 1897 (Towns.).

933. **Eupatorium Torreyanum** Short (Thoroughwort)

In barren pine woods, frequent. Specimens: Tryon, July 18, 1921 (PT. no. 972).

934. **Eupatorium compositifolium** Walt. (Thoroughwort)

Frequent in dry open soil, especially in the Cecil clays. Specimen: Columbus, Aug. 20, 1921 (PT. no. 1321).

935. **Eupatorium scabridum** Ell. (Thoroughwort)

So far as I know, this species has not been previously reported from North Carolina. It is a southern coastal plain plant. Rare, in the Congaree soils. Specimen: Moist shady thickets along the lower Pacolet, Aug. 20, 1921 (PT. no. 1326).

936. **Eupatorium rotundifolium** L. (Thoroughwort)
Eupatorium Marrubium Walt.
Uncasia rotundifolia Greene

A coastal plain species, rather anomalous here, and indeed collected only once. Specimen: Side of Tryon range, July 20, 1899 (Towns.).

937. **Eupatorium perfoliatum** L. (Boneset)
Eupatorium connatum Michx.
Uncasia perfoliata Greene

A common species of low alluvial grounds, marshy meadows, flowers in autumn. (Noted)

938. **Eupatorium urticaefolium** Reichard (White Snakeroot)
Ageratum altissimum L.
Eupatorium ageratoides L. f.
Krystenia altissima Greene

This attractive plant is the cause of a dire disease, "milk sick," often called "lead poisoning" by the natives. The plant is believed to grow where there is lead in the soil, but this is entirely fallacious. The disease is also sometimes attributed to the eating of buckeye leaves by cows, but this too is mythical. About the fatal nature of the disease there is no doubt, and there were in 1917 two deaths in the mountains attributed to this disease. The plant grows in rich cool woods, chiefly in the mountains, in Porter's loam. Specimens: Vaughan's Gap, S. C., Aug. 13, 1921; "Dark Corners," S. C., Aug. 14, 1921; rich woods, Tryon, Aug. 24, 1921 (PT. nos. 1235, 1223, 1403). Hogback Mt., Sept. 17, 1927 (Wherry).

939. **Eupatorium aromaticum** L.
Eupatorium ceanothifolium Muhl.
Krystenia aromatica Greene

This plant, chiefly of the coastal plain, for which I know no common name and which is, incidentally, not aromatic, is found in copses, rather rarely. Specimens: Huston Farm, near Columbus, Oct. 1897 (Towns.). Miss Wright reports it from Tryon in Sept.

940. **Conoclinum coelestinum** L. (Mist-flower)
Eupatorium coelestinum L.

This beautiful little flower has been collected but once. Specimen: Huston Farm, east of Columbus, Sept. 8, 1897 (Towns.).

941. **Kuhnia eupatorioides** L.

This plant, which ranges far into the Middle West is, if not out of its normal range here, at least rather an unusual "find" in a mountain forest country; indeed it seems to have been collected just once. Specimen: Huston Farm, east of Columbus, Sept. 6, 1897 (Towns.).

942. **Liatris polyphylla** Small (Blazing Star. Sky Rocket)
Lacinaria polyphylla Small

In dry meadows, occasional. Specimen: Near the trestle, on the state line, Aug. 11, 1921 (PT. no. 1154).

943. **Liatris microcephala** (Small) K. Schum. (Blazing Star. Sky Rocket)
Lacinaria microcephala Small

Dry woods and meadows. Specimen: Columbus, Aug. 4, 1897 (Towns.).

944. **Liatris scariosa** (L.) Willd. (Blazing Star. Sky Rocket)
Serratula scariosa L.
Lacinaria scariosa Hill

Not infrequent in dry meadows. Specimen: Fox Mt., Sept. 1897 (Towns.). Hogback Mt., Sept. 18, 1927 (Pennell no. 14236).

945. **Liatris pilosa** (L.) Willd. Blazing Star. Sky Rocket.
Serratula pilosa L.
Lacinaria pilosa Ktze.

Frequent in dry woods and open meadows. Specimens: Tryon, Aug. 4, 1897 (Towns.). Columbus, July 29, 1921 (PT. no. 1093).

946. **Liatris spicata** (L.) Willd. (Blazing Star. Sky Rocket)
Serratula spicata L.
Lacinaria spicata Hill
Liatris squarrulosa Michx.

Rather frequent in dry deciduous woods. Specimen: East of Columbus, Aug. 16, 1899 (Towns.).

Var. **montana** Gray
Lacinaria spicata var. *pumila* Porter

This more handsome variety may be more widespread in the mountains than would appear from the one collection of recent date. Specimen: Hogback Mt., Sept. 27, 1927 (Wherry).

947. **Liatris graminifolia** (Walt.) Willd. (Blazing Star. Sky Rocket)
Anonymos graminifolia Walt.
Lacinaria graminifolia Ktze.

Not infrequent in clayey meadows. Specimen: Columbus, Aug. 4, 1897 (Towns.).

948. **Arctium minus** Bernh. (Burdock)
Lappa minor Hill
Arctium nemorosum Lejeune

A harmful European weed; not as yet common except around rubbish heaps of the towns. Specimen: Tryon, May 23, 1926 (PT. no. 2267).

949. **Cirsium lanceolatum** (L.) Hill (Common or Bull Thistle)
Carduus lanceolatus L.
Cnicus lanceolatus Willd.

A harmful European weed, frequent but not abundant. (Noted).

950. **Cirsium altissimum** (L.) Spreng. (Thistle)
Carduus altissimus L.
Cnicus altissimus Willd.

This native field and wood thistle is reported by Miss Wright in her list of Tryon plants. Other collectors do not seem to have found it, but its presence is perfectly possible and as it occurs in Henderson County on the west it may be admitted to our flora.

951. **Centaurea Cyanus** L. (Bluebottle. Bachelor's Button)

European garden flower, commonly escaped. Specimen: Tryon, May 23, 1926 (PT. no. 2276).

952. **Pluchea petiolata** Cass. (Marsh Fleabane)

This rather singular plant, though ranging somewhat widely in the southern and middle western states, is seldom taken by collectors, and in our area it represents quite a "find," indeed it needs re-finding as it has been collected only once. Specimen: Low grounds, Columbus, October, 1899 (Towns.).

953. **Antennaria plantaginifolia** (L.) Richards (Pussy's Toes. Lady's Tobacco. Everlasting)
Gnaphalium plantaginifolium L.

Very common in deciduous woods and thickets. Specimens: Side of Tryon range, April 17, 1897 (Towns.). Dry woods, Columbus, April 15, 1923; moist banks, "Valhalla," April 19, 1922; Tryon, May 23, 1926 (PT. nos. 1846, 1655, 2152).

954. **Antennaria solitaria** Rybd. (Pussy's Toes. Ladies' Tobacco. Everlasting)

Common in deciduous woods and thickets. Specimens: Tryon, April 13, 1919 (Day). Melrose, April 10,1923; Tryon, April 18, 1923; Melrose, April 16 and 20, 1922 (PT. nos. 1808, 1857, 1688, 1610).

955. **Antennaria occidentalis** Greene (Pussy's Toes. Ladies' Tobacco. Everlasting)

Less frequent than the preceding, woods and fields. Specimen: Tryon, April 13, 1919 (Day).

956. **Antennaria neglecta** Greene (Pussy's Toes. Ladies' Tobacco. Everlasting)

Infrequent, dry meadows and woods. Specimen: Tryon, March 30, 1919 (Day).

957. **Gnaphalium polycephalum** Michx. (Common Everlasting)
Gnaphalium obtusifolium L. (?)

Very common, dry deciduous woods, fallow fields, etc. Specimen: Woods, Columbus, Nov. 1926 (PT. no. 2403).

958. **Gnaphalium purpureum** L. (Purple Cudweed)

Common in dry deciduous woods, fallow fields, pastures, and as a native lawn weed. Usually a humble and homely weed, it is sometimes almost beautiful when the purple bracts are brightly colored. Specimens: Side of Tryon range, May 8, 1897 (Towns.). Tryon, May 5, 1926 (PT. no. 2139).

959. **Ambrosia trifida** L. (Great Ragweed)

In rich soil, along roadways in shade, rubbish heaps, etc. This bad hay-fever weed is rather common but happily not so abundant in some places. It begins to pollinate in August and may so continue till the end of September. (Noted).

960. **Ambrosia elatior** L. (Low Ragweed. Roman Wormwood)
Ambrosia artemisiaefolia T. & G., not L.

Roadsides, fallow fields, lawns, and rubbish heaps, not in forest land. Unfortunately abundant; a hay-fever weed with the same pollinating dates as the preceding. Specimen: Tryon, in fruit, Nov. 3, 1926 (PT. no. 2388). The spiny fruits aid in its wide dissemination and are a pest to man and animal.

961. **Cacalia atriplicifolia** L. (Indian Plantain)
Mesadenia atriplicifolia Raf.
Conophora atriplicifolia Nieuwl.

In rich mountain woods, not frequent. Specimens: Tryon, July 6, 1897 (Towns.). Melrose, June 24, 1921 (PT. no. 699).

962. **Cacalia reniformis** Muhl. (Indian Plantain)
Mesadenia reniformis Raf.
Conophora reniformis Nieuwl.

In deep rich mountain woods, Porter's soils. Specimen: Spring Mt. Park, July 27, 1897 (Towns.). Rare.

963. **Senecio glabellus** Poir. (Butter-weed)
Senecio lobatus Pers.
Senecio lyratus Michx., not L.

Rare, in low ground. Specimen: Columbus, March 1899 (Towns.).

964. **Senecio obovatus** Muhl. var. **rotundus** Britton (Groundsel)

Not infrequent, in dry woods. Specimen: Columbus, April 15, 1923 (PT. no. 1848).

965. **Senecio pauperculus** Michx. (Groundsel)
Senecio Balsamitae var. *pauperculus* Fernald

This odd plant seems to have been collected but once, but the specimen of it is authentic. Specimen: Tryon, May 8, 1911 (Day).

966. **Senecio millefolium** T. & G. (Groundsel)
Senecio Memmingeri Britton

This handsome and very singular plant is rare with us, in shaded mountain soils, an Appalachian endemic, but it has caught the eyes of two of the ablest collectors in the region. Specimens: Summit of Tryon Peak, May 27, 1897 (Towns. *Fide* Greenman). "Skuyuka," May 1899 (Church.).

967. **Senecio Smallii** Britton (Groundsel)

The commonest of the genus, in dry open soil, or dry woods, throughout. Specimens: Columbus, April 28, 1899 (Towns.). Tryon, May 1899 (Church.). Tryon, May 1918 (Millsp. no. 4067). Tryon, May 6, 1926 (PT. no. 2150).

968. **Senecio tomentosus** Michx. (Groundsel)

Frequent in dry woods. Specimen: Tryon, April 18, 1923 (PT. no. 1855).

969. **Solidago petiolaris** Ait. var. **angustata** (T. & G.). Gray (Goldenrod)

This belongs to a somewhat unusual group of the great genus, and is also somewhat unusual outside the Middle West. It seems to have been collected but once. Specimen: Columbus, Oct. 1897 (Towns.).

970. **Solidago Curtisii** T. & G., var. **pubens** (M. A. Curtis) Gray (Goldenrod)

An Appalachian endemic; rare, in mountain woods. Specimens: Spring Mt. Park, Aug. 29, 1897 (Towns.).

971. **Solidago Buckleyi** T. & G. (Goldenrod)

An Appalachian endemic, mountain and foothill woods. Specimen: Tryon, Oct. 18, 1926 (PT. no. 2391).

972. **Solidago bicolor** L. (White Goldenrod)
Solidago alba Mill.

This striking plant is rather unusual with us, in dry woods. Specimens: Columbus, Oct. 1897 (Towns. The leaves are glabrous and practically entire). Hogback Mt., Sept. 17, 1927 (Wherry).

973. **Solidago erecta** Pursh (Goldenrod)

In dry mountain woods, rare. Specimen: Hogback Mt., Sept. 17, 1927 (Wherry).

974. **Solidago monticola** T. & G. (Goldenrod)
Solidago roanensis Porter

An Appalachian endemic common in mountain woods. Specimens: Columbus, Oct. 1897 (Towns.). Tryon, Oct. 18, 1926 (PT. no. 2392). Hogback Mt., Sept. 18, 1927 (Wherry).

975. **Solidago Boottii** Hook. (Goldenrod)

Occasional in dry woods. Specimens: Spring Mt. Park, Sept. 2, 1897 (Towns.). Melrose Mt., Sept. 18, 1927 (Wherry & Pennell no. 14218).

976. **Solidago yadkinensis** (Porter) Small (Goldenrod)

Distinctly an odd species, endemic to piedmont North Carolina. A single collection. Specimen: Tryon, June (!) 23 1897 (Towns. The date may be an error).

977. **Solidago juncea** Ait. (Goldenrod)

Frequent in woods. Specimen: Hogback Mt., Sept. 17, 1927 (Wherry).

Var. **scabrella** (T. & G.) Gray

Specimen: Godshaw Hill, Nov. 3, 1926 (PT. no. 2416).

978. **Solidago suaveolens** Schoepf. (Goldenrod)
Solidago odora Ait.

Occasional in woods and fields. Specimen: Tryon, Aug. 10, 1897 (Towns.).

979. **Solidago rugosa** Mill. var. **aspera** (Ait.) Fernald (Goldenrod)
Solidago aspera Ait.

Frequent in woods and fields. Specimens: Tryon, Oct. 1926, and Columbus, Oct. 1926 (PT. nos. 2389, 2399).

980. **Solidago nemoralis** Ait (Goldenrod)

Infrequent, in mountain woods. Specimen: Hogback Mt., Sept. 17, 1927 (Wherry).

Solidago speciosa Nutt. and *S. latifolia* L. have been reported by Miss Wright. No specimens seen, and not reported from Henderson County, but their presence is by no means impossible. This genus has been rather neglected by collectors, and undoubtedly more species will be found when the autumn flora is better known.

981. **Brachychaeta sphacelata** (Raf.) Britton (False Goldenrod)
Solidago sphacelata Raf.
Solidago cordata Short

Infrequent, in dry deciduous woods. Specimens: Tryon and Spring Mt. Park, Sept. 1897 (Towns.).

982. **Chrysopsis mariana** (L.) Nutt. (Golden Aster)
Inula mariana L.

Very common in dry woods and fields throughout. Specimens: Tryon, Aug. 21, 1897 (Towns.). Tryon, Dec. 5, 1918 (Day). Hogback Mt., Aug. 14, and "Dark Corners," Aug. 13, 1921; Lynn, Oct. 1926 (PT. nos. 1246, 1228, 2357). Hogback, Sept. 17, 1927 (Wherry).

983. **Chrysopsis graminifolia** (Michx.). Nutt. (Golden Aster)
Inula mariana Michx.

Common on the Cecil soils of the piedmont, dry open fields, roadsides, etc. Specimens: Tryon, Aug. 10, 1897 (Towns.). Tryon, Nov. 23, 1918 (Day). Tryon, in fruit, Nov. 6, 1926 (PT. no. 2382). Hogback Mt., Sept. 17, 1927 (Wherry).

Note: In the treatment of the genus *Aster* which follows I have given considerable weight to the views of Professor Sanford Burgess's work, "Species and Variations of Biotian Asters, with discussion of variability in Aster" (*Mem. Torr. Bot. Cl.* 13: 1906) and also his treatment of the genus in Small's "Flora of the Southeastern States," ed. 1.

The tendency of recent years has been to reject Burgess's work, upon the grounds that he has made too many species. But in identifying my specimens from this region, and those of my fellow collectors, I found that individual specimens could be recognized and named by Prof. Burgess's treatment, and that by other treatments of the genus they could not.

984. **Aster divaricatus** L. (Frostflower. Farewell-Summer)

This beautiful species is common in deep mountain woods, on moist Porter soils. Specimens: Tryon Mt., Dec. 28, 1920, and Pearson's Falls, Sept. 12, 1921 (PT. nos. 1583, 1505).

Var. **deltoideus** Burgess

Possibly widespread, but I have seen a single specimen: Columbus, Oct. 1899 (Towns.).

Var. **fontinalis** Burgess

Found in grottoes and on dripping rocks, near waterfalls, etc. Specimens: Vaughan's Creek, on dripping rocks, Aug. 13, 1921, and on dripping rocks, Hogback Mt., Aug. 14, 1921 (PT. nos. 1226, 1251, 1258). Some of these specimens were parasitized by *Cuscuta rostrata*.

985. **Aster alleghaniensis** Burgess (Frostflower. Farewell-Summer)

Burgess (*Mem. Torr. Bot. Cl.* **13**: 337) cites as a type specimen of this species Townsend's specimen from Columbus, Oct. 1897, and says of it: "about 12 short broad rays; no cordation."

986. **Aster multiformis** Burgess (Frostflower. Farewell-Summer)

In deep mountain woods, especially along cold brooks. Specimen: Spring Mt. Park, July 31, 1899 (Towns.).

987. **Aster Proteus** Burgess (Frostflower. Farewell-Summer)

An interesting, many-formed species of which I have seen a single specimen: Tryon, June 21, 1897 (Towns.).

988. **Aster patens** Ait. (Frostflower. (Farewell-Summer)
Aster undulatus Ell. not L.
Aster amplexifolius Michx.

Abundant; a handsome species, with its deep purple-blue rays. Found in deep mountain woods, Pearson's Falls, or even more commonly on piedmont soils of the richer sort. Specimens: Pearson's Falls, Sept. 12, 1921, and Tryon, Nov. 3, 1926 (PT. nos. 1516 1/2, 2406, 2408, 2410, 2411).

989. **Aster phlogifolius** (Nees) Muhl. (Frostflower. Farewell-Summer)

A specimen of Townsend's, from Spring Mt. Park, Sept. 1897, in the Cornell Herbarium, was identified for me by the courtesy of Dr. Wiegand.

990. **Aster azureus** Lindl. (Frostflower. Farewell-Summer)

Not infrequent in low wet woods. Specimen: Tryon, Aug. 24, 1921 (PT. no. 1374).

991. **Aster Shortii** Lindl. (Frostflower. Farewell-Summer)

A pretty Appalachian and Middle Western Species. One specimen: Columbus, Oct. 1897 (Towns.).

992. **Aster undulatus** L. (Frostflower. Farewell-Summer)
Aster diversifolius Michx.
Aster sagittifolius Ell.

In dry woods. Specimen: Tryon, July 29, 1897 (Towns.).

993. **Aster cordifolius** L. var. **alvearius** Burgess (Frostflower)

Woods and thickets. Specimen: Tryon, June 21, 1897 (Towns.).

994. **Aster Lowrieanus** Porter (Frostflower. Farewell-Summer)

Open woods and thickets, common. Specimens: Tryon Mt., Dec. 29, 1920; rich woods, Pearson's Falls, Sept. 12, 1921; Tryon, Oct. 1926 PT. nos. 1584, 1517, 2414).

995. **Aster multiflorus** L. (Frostflower. Farewell-Summer)

Dry sandy soil, infrequent. Specimen: Tryon, Oct. 1926 (PT. no. 2421).

996. **Aster dumosus** L. (Frostflower. Farewell-Summer)
A. sparsiflorus Michx.

In sandy soil, occasional. Specimen: Near Lynn, Sept. 16, 1897 (Towns.).

Var. **gracilentus** T. & G.

Fox Mt., Aug. 31, 1897 (Towns.). In Henderson County just across our western borders, occurs var. *cordifolius* (Michx.) T. & G.

997. **Aster vimineus** Lam. (Frostflower. Farewell-Summer)

In moist soil, rare. Specimen: Tryon, Oct. 1926 (PT. no. 2422).

998. **Aster lateriflorus** (L.) Britton (Frostflower. Farewell-Summer)
Aster diffusus Ait.

May be present in our area. It is represented only by specimens of the following varieties, so far as I know:

Var. **hirsuticaulis** (Lindl.) Porter

Reported from Tryon by Miss Wright.

Var. **grandis** Porter

In open fields. Specimen: Pacolet Valley, Oct. 1926 (PT. no. 2412).

999. **Aster concolor** L. (Frostflower. Farewell-Summer).
Virgula concolor Raf.

This is reported from Polk County by Miss Wright. There are no specimens, but it occurs in Henderson Co.

1000. **Aster Tradescanti** L. (Frostflower. Farewell-Summer)
Aster miser Ait.

Rather frequent, in dry open soil, especially the foothills and piedmont. Specimen: Tryon, Nov. 3, 1926 (PT. no. 2407).

1001. **Aster paniculatus** Lam. (Frostflower. Farewell-Summer)

Common in dry open soils throughout. Specimen: Tryon, Sept. 12, 1921 (PT. no. 1512).

Var. **bellidiflorus** (Willd.) Burgess

Perhaps frequent. Only one specimen at present: Railroad track, Tryon, May 23 (!), 1926 (PT. no. 2260).

Var. **simplex** (Willd.) Burgess

Not infrequent; specimens: Columbus, without further data, (Towns.). Tryon, Nov. 23, 1926 (PT. no. 2413).

1002. **Aster virgatus** Ell. (Frostflower. Farewell-Summer)
Aster purpuratus Nees

This occurs in Miss Wright's list of Tryon plants; it is not in Memminger's Henderson County list, but it is perfectly possible and indeed probable that this species occurs with us and I see no reason to doubt Miss Wright's report, but there are no specimens.

1003. **Aster ericoides** L. (Frostflower. Farewell-Summer)

In dry open soil, rare. Specimen: East of Columbus, Nov. 24, 1926 (PT. no. 2423).

1004. **Aster salicifolius** Ait. (Frostflower. Farewell-Summer)

Frequent in woods. Specimens: Tryon, Aug. 9, and Sept. 6, 1921 (PT. nos. 1138, 1486).

1005. **Aster junceus** Ait. (Frostflower. Farewell-Summer)

Frequent in open woods and upland fields. A beautiful species with its slender rose-lilac rays. Specimen: Godshaw Hill, Nov. 9, 1926 (PT. no. 2409).

1006. **Aster puniceus** L. (Frostflower. Farewell-Summer)

There are no specimens from our area, but Miss Wright, who reports it in her Tryon list could hardly have mistaken this striking species, and Memminger gives it from Henderson County, our neighbor on the west.

1007. **Aster linariifolius** L. (Frostflower. Farewell-Summer)
Ionactis linariifolius Greene
Aster rigidus L.
Chrysopsis linariifolius Nutt.
Diplopappus linariifolius Hook.

This pretty little plant is reported in Miss Wright's list from Tryon It occurs in Henderson County, and seems quite admissible even in the absence of specimens.

1008. **Doellingeria infirma** (Michx.) Greene (Flat-topped Aster)
Aster infirma Michx.
Aster cornifolius Muhl.
Chrysopsis humilis Nutt.
Diplopappus cornifolius Less.

A striking plant both as to foliage and flowers, frequent in woods, especially at the foot of the mountains. Specimens: Tryon, 1897 (Towns.). Tryon, Aug. 9, 1921; Columbus, Nov. 1926 (PT. nos. 1136, 2419). Probably Miss Wright's report of *Aster umbellatus* belongs here.

Boltonia asteroides (L.) L'Her. is in Miss Wright's Tryon list. It does not occur in Henderson County and seems doubtful for our flora, but not impossible.

1009. **Sericocarpus asteroides** (L.) BSP. (White-topped Aster)
Conyza asteroides L.

Abundant in open fields, red clay soil of the piedmont, or sometimes in mountains woods. Specimens: Tryon, June 23, 1897 (Towns.). Tryon, June 25, 1897 (Bilt. Herb. no. 109a). Dry woods, Whiteoak Mt., July 21, and open fields and roadsides, June 30, 1921 (PT. nos. 1003, 793).

1010. **Sericocarpus linifolius** (L.) BSP. (White-topped Aster)
Conyza linifolius L.

Very common on the Cecil clays, open fields and roadsides. Specimens: Tryon, June 23, 1897 (Towns.). Tryon, June 20, 28, 1921 (PT. nos. 653, 725).

1011. **Erigeron pulchellus** Michx. (Robin's Plantain)
Erigeron bellidifolius Muhl.

Pretty, common flower of early spring, beginning to bloom in March. It is found throughout in shade, but prefers mossy banks. Specimens: Columbus, April 8, 1897 (Towns.). In the Pacolet Gorge, April 20, 1923, and Tryon, April 16, 1922 (PT. nos. 1863, 1611).

Var. **Townsendii** var. nov.

Dentes foliorum basale magni; stirpes robustae; ligulae angustissimae, longissimae.

Specimens: "Glen Walden," Tryon, May 6, 1926 (Peattie no. 2141). In the crevices of dripping granite rocks.

This new variety, which I take pleasure in naming for the foremost Tryon collector (see Introduction), may be characterized as follows: Leaves of the basal rosette 1–3, often 9 cm. long and 5–6 cm. broad; rhomboid, scarcely acute at tip, base acute; teeth very sparse, but large and apiculate; stems robust and long; cauline leaves sessile, spatulate-oblong, acute at both ends; rays very narrow, very long.

1012. **Erigeron ramosus** (Walt.) BSP. (Daisy Fleabane)
Doronicum ramosum Walt.
Erigeron strigosus Muhl.
Erigeron ambiguum Nutt.
Erigeron nervosum Pursh

Very common throughout, but especially in open fields, on the Cecil clays. In 1919 I collected a series of specimens of this and the following that practically intergraded, so variable are the somatic characters. Specimens: Side of Tryon range, June 19, 1899 (Towns.). Tryon, May 23, 1926 (PT. no. 2236).

1013. **Erigeron annuus** (L.) Pers. (Sweet Scabious)
Aster annuus L.
Erigeron heterophyllus Muhl.

Common in dry open fields, especially sandy soil, and as a weed in cultivation. Specimens: Side of Tryon range, June 19, 1899 (Towns.). Tryon, May 23, 1926 (PT. no. 2215).

1014. **Leptilon canadensis** (L.) Britton (Horseweed)
Erigeron canadensis L.
Senecio ciliatus Walt.

This big, homely weed of cultivated ground may or may not have formed part of the original flora. It blooms all summer and is too common. (Noted).

1015. **Marshallia obovata** (Walt.) Beadle & Boynton

Infrequent, river-banks and open woods, on the piedmont. Specimen: Tryon, May 14, 1919 (Day).

Var. **platyphylla** (Curtis) Beadle & Boynton. More frequent.

Specimens: Tryon, May 24, 1897b (Towns.). Tryon, May 1899 (Church.).

1016. **Marshallia grandiflora** Beadle & Boynton

There appears to be but one collection of this species, which is more clearly distinct than Gray's "Manual" admits. Specimen: Saluda, July 22, 1899 (Bilt. Herb. no. 4215a).

1017. **Parthenium integrifolium** L. (Cutting Almond)

Not infrequent in dry open soil, roadways, etc. Specimens: Tryon, July 12, 1899 (Towns.). Tryon, June 29, 1921 (PT. no. 778). It begins to bloom in May, and continues till fall. Has a rank, rose-geranium and terebenthine odor.

1018. **Parthenium auriculatum** Britton (Cutting Almond)

Frequent; an Appalachian endemic, meadows and woods. Specimens: Tryon, May 17, 1919 (Day). In dry soil, "The Shoals," Aug. 20, 1921 (PT. no. 1300). Hogback Mt., Sept. 17, 1927 (Wherry). Flowering dates and odor as in the preceding.

1019. **Polymnia uvedalia** L. (Leafcup)
Osteospermum uvedalia L.
Polymniastrum uvedalia Small & Carter

Fairly frequent in rich mountain woods. Specimens: Mountainsides, Sept. 2, 1897 (Towns.). Melrose, Aug. 8, 1921 (PT. nos. 1104, 1105).

1020. **Silphium terebinthinaceum** Jacq. (Prairie-Dock)

A single specimen of this middle-western plant: Tryon, July 21, 1897 (Towns.).

1021. **Silphium Astericus** L. (Rosin-weed)

A single specimen of this southern plant: "Huston Farm" near Columbus, Aug. 11, 1897. (Towns.). There is also a Bilt. Herb. specimen from Chimney Rock, Sept. 7, 1898.

1022. **Silphium compositum** Michx. (Rosin-weed)

Infrequent, in open woods or fields on the piedmont. Specimen: Tryon, Aug. 29, 1921 (PT. no. 1417).

1023. **Silphium dentatum** Ell. (Rosin-weed)

Occasional in dry woods and fields on the piedmont. Specimen: Aug. 24, 1921 (PT. no. 1368, a, b).

1024. **Silphium Elliottii** Small (Rosin-weed)

Occasional in rich foothill woods. Specimen: "Glen Walden," Tryon, June 29, 1921 (PT. no. 777).

1025. **Chrysogonum virginianum** L. (Golden-star)

Common in dry woods and fields. This beautiful little plant, growing very close to the ground, often in sterile and unattractive places, deserves attention of gardeners. I transplanted it with ease in Tryon to a rockery, where it makes a brilliant carpet. It often begins to bloom in March. Specimens: South of Columbus, April 2, 1897 (Towns.). Tryon, May 1899 (Church.). Tryon, April 25, 1919 (Day). Tryon, April 16, 1922 (PT. no. 1618).

1026. **Heliopsis scabra** Dunal (Ox-eye)

A single specimen: Lynn, Sept. 6, 1897 (Towns.). This specimen is exceptional in having smooth stems; the lower petioles are long and winged. In other respects it conforms with descriptions of the species.

1027. **Heliopsis helianthoides** (L.) Sweet (Ox-eye)
Buphthalmum helianthoides L.
Heliopsis laevis Pers.

Frequent, shaded banks and lower wooded slopes of the mountains. Specimens: Spring Mt. Park, Aug. 20, 1897 (Towns.). Melrose, Sept. 12, 1921 (PT. no. 1494, A.).

1028. **Tetragonotheca helianthoides** L.

Frequent in sandy soil or dry open woods. Specimens: Fox Mt., June 2, 1897 (Towns.). "Skuyuka," May 1899 (Church.). Along the railroad track above Tryon, June, 1900 (Miss Wright).

1029. **Rudbeckia hirta** L. (Black-eyed Susan)

Common, dry woods and open fields. Specimens: Side of Tryon range, June 15, 1897 (Towns.). Tryon, July 18, 1921 (PT. no. 971).

1030. **Rudbeckia Brittonii** Small (Black-eyed Susan)

Common, a well marked species, not merely "a mountain phase" as suggested in Gray's "Manual." Specimens: Columbus, without further data (Towns.). Woods and fields, Tryon, June 29, 1921 (PT. no. 775).

1031. **Rudbeckia monticola** Small. (Black-eyed Susan)

Also a well-marked species. Frequent, open ground of the foothills. Specimen: Tryon, June 20, 1921 (PT. no. 644, 646).

1032. **Rudbeckia laciniata** L. (Cone-flower)

In thickets and mountain fields and woods. Specimen: Open banks, Melrose, Sept. 12, 1921 (PT. no. 1492, A.).

Var. **humilis** Gray.

Specimen: Spring Mt. Park, Aug. 12, 1897 (Towns.).

Miss Wright in her list of Tryon plants reports *Brauneria purpurea*, the splendid Purple Cone-flower. It does not occur in Memminger's Henderson County list, and it is surprising that the many collectors since Miss Wright's day have never caught sight of this brilliant flower. Yet her report is not quite capable of being ignored, since along the railroad track near Black Mountain I saw quantities in bloom, June 17, 1921, so that it certainly occurs in this part of the state.

1033. **Lepachys pinnata** (Vent.) T. & G.
Ratibida pinnata Barnhart
Lepachys pinnatifida Raf.

This common weed of open fields was noted, blooming in summer.

1034. **Helianthus occidentalis** Riddell (Sunflower)

So far only one specimen has been taken, but it may be more wide spread. Specimen: In mountain woods, Hogback, Sept. 17, 1927 (Wherry).

1035. **Helianthus atrorubens** L. (Sunflower)

Abundant in dry woods, mountains and piedmont. Specimens: Spring Mt. Park, Aug. 16, 1897 (Towns.). Columbus, July 29, Hogback Mt., at the summit, Aug. 14, Tryon, Aug. 24, 1921, and Oct. 18, 1926 (PT. nos. 1090, 1247, 1371, 2397).

1036. **Helianthus divaricatus** L. (Sunflower)

Dry thickets, occasional, on the piedmont. Specimen: Tryon, June 7, 1897 (Towns.).

1037. **Helianthus decapetalus** L. (Sunflower)

Occasional, thickets and stream-banks, Specimen: Melrose, Sept. 12, 1921 (PT. no. 1491).

1038. **Helianthus strumosus** L. (Sunflower)

Frequent, river-banks and thickets. Specimens: Spring Mt. Park, Aug. 23, 1897 (Towns.). Tryon, Aug. 29, 1921 (PT. no. 1420).

1039. **Helianthus hirsutus** Raf. (Sunflower)

Thickets, in dry soil and along stream banks. Specimens: Spring Mt. Park, Aug. 14, 1897 (Towns.). River banks, Tryon, Aug. 24, 1921, and moist banks, Melrose, Sept. 12, 1921 (PT. nos. 1375, 1492).

1040. **Verbesina alternifolia** Britton (Yellow Ironweed)
Coreopsis alternifolia L.
Actinomeris squarrosa Nutt
Verbesina Coreopsis Michx
Actinomeris alternifolia DC.
Ridania alternifolia Ktze.
Ridan alternifolia Britton

Occasional in damp or wet woods. Specimen: Lynn, Sept. 5, 1897 (Towns.).

1041. **Verbesina paniculata** Walt. (Yellow Ironweed)
Actinomeris paniculata Small

So far as I know this plant has not previously been reported from as far north as this state. Specimen: Along the railroad, in rich woods, Melrose, Aug. 8, 1921 (PT. no. 1099).

1042. **Verbesina occidentalis** (L.) Walt. (Crownbeard)
Siegesbeckia occidentalis L.
Verbesina Siegesbeckia Michx.
Phaethusa occidentalis Britton

Common in woods, roadsides, and clearings, throughout. Specimens: Side of Tryon range, Sept. 8, 1897 (Towns.). Roadsides, Tryon, Sept. 3, 1921, and woods, Oct. 1926 (PT. nos. 1451, 2400). Tryon, Sept. 15, 1926 (Hunnew, no. 9950).

1043. **Coreopsis pubescens** Ell.
Coreopsis auriculata Schkuhr., and Hort., not L.

This superb flower, often cultivated, occurs in dry open soils occasionally; it seems confined to the Tryon range and its foothills. It occurs at least sometimes on outcrops of Henderson granite, and on Porter sandy loams. Specimens: Columbus, 1897 (Towns.). "Sunset Rock," White Oak Mt., July 26, 1921 (PT. no. 1006, 1007).

1044. **Coreopsis auriculata** L.

On open soils of the Cecil series, in the eastern part of the county. Specimen: 3 miles north of Millspring, May 27, 1927 (Wherry).

1045. **Coreopsis latifolia** Michx.

A beautiful Appalachian endemic, frequent on Porter's soils of the mountains. Specimens: Side of Tryon range, June 30, 1897 (Towns.). Dry woods, Hogback Mt., Aug. 14, 1921, and Vaughan's Gap, Sept. 6, 1921 (PT. nos. 1245, 1480).

1046. **Coreopsis major** Walt.
Coreopsis senifolia Michx.

An attractive flower often cultivated, frequent in woods and fields of the piedmont and foothills. Specimens: "Huston place" between Columbus and Millspring, June 26, 1897 (Towns.). Tryon, June 29, 1921 (PT. no. 776).

Var. **stellata** (Nutt.) Robinson
Coreopsis senifolia var. *stellata* T. & G.
Coreopsis Oemleri Ell.
Coreopsis major var. *Oemleri* Britton

Commoner than the typical species is this southern variety. Specimens: Tryon, 1897 (Towns.). Tryon, in fruit, Nov. 24, 1918 (Day).

Six miles northeast of Millspring, on the Rutherfordton road, three miles from the county line, May 27, 1927 (Wherry.)

1047. **Coreopsis delphinifolia** Lam.

Rather frequent in open soils of the Cecil series, on the piedmont. Specimen: Columbus, Aug. 27, 1897 (Towns.).

1048. **Coreopsis tripteris** L.

This occurs in Miss Wright's Tryon list, and is known from Henderson County; the report may be confidently accepted. *Coreopsis verticillata* occurs just south of our borders, in Spartanburg county.

1049. **Bidens frondosa** L. (Beggar-ticks)

This is reported in Miss Wright's list; it occurs in Henderson County, and may be accepted as undoubtedly present. It occurs in damp ground and blooms in summer.

1050. **Bidens bipinnata** L. (Spanish needles)

In damp soil, common. Specimens: Tryon, Aug. 10, 1897 (Towns.). Roadsides, Tryon, Sept. 12, 1921, and meadows, in fruit, Dec. 29, 1920 (PT. nos. 1514, 1588, 1589).

1051. **Galinsoga ciliata** (Raf.) Blake
Galinsoga parviflora Cav. var. *hispida* DC.
Galinsoga aristatula Bicknell

Ugly little tropical weed, confined to alleys of towns, manure heaps, etc. Specimen: Tryon, May 24, 1926 (PT. no. 2265).

1052. **Anthemis Cotula** L. (Dog Fennel)
Anthemis foetida Lam.
Maruta Cotula DC.

Little European barnyard weed with a vile odor. Specimen: Tryon, June 24, 1921 (PT.).

1053. **Achillea Millefolium** L. (Yarrow)

Very common in meadows throughout, especially grazed land. Weed-like but native. Specimen: Tryon, May 23, 1926 (PT. no. 2225). It blooms from this date until autumn.

1054. **Leucanthemum vulgare** L. (White Daisy)
Leucanthemum Leucanthemum Rydb.
Chrysanthemum vulgare Lam.
Chrysanthemum Leucanthemum L.

Common as a pasture weed, naturalized from Europe. Specimen: Tryon, June 24, 1921 (PT.). Tryon, May 1918 (Millsp. no. 4130).

An old farmyard medicinal herb and garden flower is *Tanacetum vulgare* L, the Tansy. It may occur as an escape.

1055. **Helenium autumnale** L. (Sneezeweed)

Occasional along sandy banks of the rivers, in gravelly soils of the piedmont. The flowers are very fine and occasionally cultivated. The plant is poisonous, and irritating to the nose. Specimens: Outwash plains of the Pacolet river, Aug. 25, 1921 (PT. no. 1391). Townsend has a specimen from banks of the Broad River near Chimney Rock, Aug. 18, 1897, just north of our region. The flowers are not markedly autumnal.

1056. **Krigia virginica** (L.) Willd. (Dwarf Dandelion)
Hyoseris virginica L.
Hyoseris caroliniana Walt.
Krigia caroliniana Nutt.
Cynthia virginica Beck
Adopogon carolinianum Britton

Common throughout in meadows. Specimen: Tryon, May 1918 (Millsp. no. 4080). Blooms April–Aug.

1057. **Krigia biflora** (Walt.) Blake (Cynthia)
Tragopogon virginianum L.
Hyoseris biflora Walt.
Hyoseris amplexicaulis Michx.
Krigia amplexicaulis Nutt.
Cynthia virginica D. Don
Adopogon virginicum Shafer

Frequent, moist banks throughout. Specimen: Columbus, June 17, 1897 (Towns.). Blooms May–Aug.

Krigia montana (Michx.) Nuttall is a beautiful little Appalachian endemic which I found just over our northern boundaries, on rock precipices, in July 1921. It may occur in the mountains of the northwestern portion of the county.

1058. **Chicorium Intybus** L. (Chicory)

Rare, as a ruderal weed, naturalized from Europe. Specimen: Tryon, June 24, 1921 (PT.).

1059. **Taraxacum officinale** Weber (Dandelion)
Leontodon Taraxicum L.
Taraxacum Dens-leonis Desf.
Taraxacum Taraxacum Karst.

Up to the present this familiar European weed has made headway only around alleys and manure heaps; it is not yet even common in lawns. Specimen: Village streets, Tryon, May 23, 1926 (PT. no. 2271).

1060. **Sonchus asper** (L.) All. (Sow-thistle)

Frequent as a roadside weed of European origin. Specimen: Tryon, May 1918 (Millsp. no. 4167).

1061. **Sonchus oleraceus** L. (Sow-thistle)

Frequent as a roadside weed, adventive from Europe. Specimen: Tryon, June 2, 1919 (PT. no. 0259).

1062. **Hieracium venosum** L. (Rattlesnake-weed)

Common in dry woods and open sandy places. Specimens: Tryon April 12, 1919 (Day). Tryon, May 1918 (Millsp. no. 4031). Tryon, April 16, 1919 (PT. no. 0117).

1063. **Hieracium Gronovii** L. (Hawkweed)

Occasional in poor soils under trees. Specimen: Tryon range, Sept. 2, 1897 (Towns.).

1064. **Hieracium Greenii** Porter & Britton (Hawkweed)

Occasional in dry woods. Specimen: Tryon, July 19, 1921, (PT. no. 976).

1065. **Hieracium marianum** Willd. (Hawkweed)

Common in open woods and clearings, throughout. Specimens: Top of White Oak Mt., May 25, 1899 (Towns.). Wet woods, Tryon, Aug. 2, 1921 (PT. no. 1206). South ridge of Hogback Mt., May 27, 1927 (Wherry).

1066. **Hieracium paniculatum** L. (Hawkweed)

This Appalachian endemic is common in mountain woods on the Porter soils. Specimen: "Dark Corners," Aug. 13, 1921 (PT. no. 1237).

1067. **Prenanthes alba** L. (White Lettuce)
Nabalus albus Hook.

In rich woods and thickets, frequent. Blooms in late summer and autumn. (Noted).

1068. **Prenanthes altissima** L. (Rattlesnake-root)
Nabalus altissimus Hook.

Common in rich moist woods. Specimens: Columbus, Oct. 1897 (Towns.). Tryon, Dec. 12, 1918 (Day).

1069. **Lactuca canadensis** L. (Horse-weed)
Lactuca elongata Muhl.

A common native weed of roadsides and cultivated ground. Blooms in summer and autumn. (Noted).

1070. **Lactuca scariola** L. (Prickly Lettuce)

A pernicious weed, adventive from Europe. Around towns and farms only. Blooms in summer. (Noted).

1071. **Lactuca hirsuta** Muhl. (Wild Lettuce)

A plant of dry open ground, blooming in midsummer. This is reported by Miss Wright, and, though there are no specimens, the report is perfectly reasonable and indeed even probable.

1072. **Mulgedium villosum** (Jacq.). DC. (Blue Sailors)
Lactuca villosa Jacq.

Rather frequent, borders of woods. Specimens: Columbus, Aug. 17, 1897 (Towns.). Embankments above the railway, Melrose, Aug. 8, 1921 (PT. no. 1100).

1073. **Pyrrhopappus carolinianus** (Walt.). DC. (False Dandelion)
Leontodon carolinianum Walt.
Sitilias caroliniana Raf.

In dry open soil, chiefly on the piedmont, and in fields and roadsides, but sometimes in the mountains on exposed land. The heads open wide on sunny mornings but are usually closed by noon. Specimens: Columbus, June 15, 1897 (Towns.). Railroad embankment, Tryon, June 20, 1921, and Godshaw Hill, May 26, 1926 (PT. nos. 620, 621 2239). On Rocky Spur, May 27, 1927 (Wherry).

I entered the field to begin study of the flora of the Tyron region on March 20, 1919, and collected my first plant, *Anemonella thalictroides*. The work reached completion almost twelve years later.

LIST OF NEW NAMES AND COMBINATIONS

PUBLISHED BY THE AUTHOR IN THIS CATALOGUE

Species no. 316. *Asarum rubrocinctum*, new species.
Species no. 351. *Stellaria caroliniana*, new species.
Species no. 380. *Ranunculus recurvatus* Poir. var. *fontinalis*, new variety. (Synonym: Forma *Hargeri* Weatherby.)
Species no. 719. *Rhododendron minus* Michx. var. *margarettae* (Ashe), new combination.
Species no. 795. *Phlox stolonifera* Sims. forma *violacea*, new form.
Species no. 1011. *Erigeron pulchellus* Michx. var. *Townsendii* new variety.

ABBREVIATIONS

For Biltmore Herbarium, (Bilt. Herb.)
For Churchill, (Church.)
For Hunnewell, (Hunnew.)
For Millspaugh, (Millsp.)
For Peattie, (PT.)
For Townsend, (Towns.)

ERRATA

Introduction, page 96, paragraph three, line nine; for N."L." Kimber, read: N. B. Kimber.
Introduction, page 99, paragraph eight, line two; for "1928" read: 1927.
Introduction, page 107, paragraph four, line one; for "was that," read: were those.
Introduction, page 113, line 1; for "seventy," read: eighty.
Species no. 4, line one; for "*Peteridium*," read: *Pteridium*.
Species no. 11, line one; for "*Camptosaurus*," read: *Camptosorus*.
Species no. 13, line nine; for "*substripinnatum*," read: *subtripinnatum*.
Species no. 18, line three; for "Berngh.," read: Bernh.
Species no. 21, lines one, two and three; for "*punctiloba*" read: *punctilobula*.
Species no. 30, line one; for "Spreng.," read: "Spring."
Species no. 40, paragraph two, line 7; for "branches," read: needles. And line eight; for "plain," read: plane.
Species no. 203, line seven; for "*altuensis*," read: *saltuensis*.
Species no. 233, line two; for "par.," read: part.
Species no. 316, paragraph three, line four; after "Madison County," add: New York State.
Species no. 317, line fourteen; after "but," add: in the National Herbarium.
Species 395, line 4, for "*Buettneria*," read: *Butneria*.
Family 54. For "(V)," read: Virginia Willow Family.
Species no. 463, line six; for "Ashe," read: Bailey.
Species 468, line eight, delete "probably flowering date."
Species no. 478, line four; for "species," read: specimens.
Species 516, line four; for "abundantly," read: occasionally.
Species 607, line three; for "*Toxicondendron*," read: *Toxicodendron*.
Species 614, line eighteen, (line four on page 79); for "lobes," read: teeth.
Species 649, line nine; for "*soroira*," read: *sororia*.
Species 659, line four; for "Fay," read: Day.
Species 707, line one; for "*floridum* Raf.," read: *florida* (L.) Raf.
Species 709, line seven; for "creditable," read: credible.
Species 720, second line from bottom of page; insert in the key, in apposition to the bottom line: Leaves elliptical-oblong, acute; flowers white or rose. *R. maximum*.
Species 726, after line two; add as a synonym: *Leucothoë racemosa* Gray.
Species 771, line 5; after "1897," add: (Towns.).
Species 805, line three; for "*hispida*," read: *hispidum*.
Species 829, line two; for "Mellisa," read: Melissa.
Species 848, line five: for "(Pennell)," read: (Wherry and Pennell).
Species 848, line three; same correction as in preceding.
Species 853. Delete this species entirely; it was included by an error and is not a member of this flora.
Species 855, line two, after "flowers," add: and leafy bracts.
Line nine; for "(Pennell)," read: (Wherry and Pennell).
Species 856, line two; after "species," add: with bracts much smaller than the leaves.

Line seven; (first line on page 227,) for "(Pennell)", read: (Wherry and Pennell).
Species 858, line six; for "Pennell" read: Pennell and Wherry.
Line eight, for "(Pennell)," read: (Wherry and Pennell).
Species 859, line three; for "(Pennell)" read: (Wherry and Pennell).
Species 867, line eleven, (third line on page 279;) same correction as in preceding.
Species 868, after line two; add as a synonym: *Dasystoma laevigata* Chapm.
Species 869, line ten; for "(Pennell)" read: (Wherry and Pennell).
Species 870, line 10; same correction as in preceding.
Species 873, line four; same correction as in preceding.
Species 872, line six; after "Towns." add: Spring Mt. Park, April 1897 (Bilt. Herb. no: 1855b).
Species 875, line two; for "*Leptanmium,*" read: *Leptamnium.*
Species 877, line one; for "Cance" read: Cancer.
Species 878, line six; for "this," read: that.

SUMMARY OF THE FAMILIES, WITH NUMBERS OF SPECIES

	Native Species	*Introduced Species*	*Total*
FERNS AND FERN ALLIES:			
Polypodiaceae	23		23
Osmundaceae	3		3
Ophioglossaceae	2		2
Equisetaceae	1		1
Lycopodiaceae	1		1
Selaginellaceae	2		2
Isoëtaceae	1		1
	33	0	33
CONIFERS:			
Pinaceae	9		9
FLOWERING PLANTS:			
Typhaceae	1		1
Potamogetonaceae	1		1
Alismaceae	1		1
Gramineae	62	26	88
Cyperaceae	55		55
Araceae	3		3
Commelinaceae	5		5
Juncaceae	9		9
Liliaceae	33	6	39
Dioscoreaceae	2		2
Amaryllidaceae	1		1
Iridaceae	7	1	8
Orchidaceae	15		15
Total of Monocots	195	33	228

	Native Species	*Introduced Species*	*Total*
Salicaceae	6	3	9
Juglandaceae	5		5
Betulaceae	7		7
Fagaceae	14		14
Ulmaceae	3		3
Moraceae	1	2	3
Urticaceae	3		3
Loranthaceae	1		1
Santalaceae	1		1
Aristolochiaceae	9		9
Polygonaceae	7	6	13
Chenopodiaceae		2	2
Amaranthaceae		1	1
Phytolaccaceae	1		1
Molluginaceae	1		1
Corrigiolaceae	2		2
Silenaceae	6	9	15
Portulacaceae	1	1	2
Ranunculaceae	36	3	39
Magnoliaceae	4		4
Calycanthaceae	2		2
Anonaceae	2		2
Menispermaceae	2		2
Berberidaceae	2		2
Lauraceae	3		3
Papaveraceae	1	1	2
Fumariaceae	1		1
Cruciferae	16	9	25
Crassulaceae	2		2
Saxifragaceae	12		12
Parnassiaceae	1		1
Hydrangeaceae	4	1	5
Escalloniaceae	1		1
Hamamelidaceae	3		3
Platanaceae	1		1
Rosaceae	47	8	55
Mimosaceae	1	1	2
Caesalpiniaceae	5	2	7
Fabaceae	42	14	56
Linaceae	1	1	2
Oxalidaceae	5		5
Geraniaceae	2		2
Rutaceae	1		1
Meliaceae		1	1
Polygalaceae	4		4
Euphorbiaceae	9		9
Anacardiaceae	4		4

	Native Species	*Introduced Species*	*Total*
Ilicaceae	3		3
Celastraceae	2		2
Aceraceae	5		5
Aesculaceae	1		1
Impatientaceae	2		2
Rhamnaceae	1		1
Vitaceae	7		7
Tiliaceae	5		5
Malvaceae		1	1
Guttiferae	6	1	7
Cistaceae	1		1
Violaceae	25		25
Passifloraceae	2		2
Cactaceae	1		1
Thymeleaceae	1		1
Lythraceae		1	1
Melastomaceae	2		2
Epilobiaceae	7		7
Nyssaceae	1		1
Araliaceae	2	1	3
Umbelliferae	16	2	18
Cornaceae	4		4
Pyrolaceae	2		2
Monotropaceae	3		3
Ericaceae	25		25
Diapensiaceae	1		1
Primulaceae	3	1	4
Diospyraceae	1		1
Styracaceae	2		2
Symplocaceae	1		1
Oleaceae	3	2	5
Gentianaceae	8		8
Loganiaceae	1		1
Apocynaceae	4		4
Asclepiadaceae	10		10
Convolvulaceae	9	5	14
Polemoniaceae	7		7
Hydrophyllaceae	4		4
Boraginaceae	4	2	6
Verbenaceae	3	1	4
Labiatae	33	6	39
Splanaceae	4	1	5
Scrophulariaceae	22	6	28
Orobanchaceae	3		3
Bignoniaceae	2	1	3
Acanthaceae	1		1
Phrymaceae	1		1

	Native Species	*Introduced Species*	*Total*
Plantaginaceae	3	1	4
Rubiaceae	17		17
Loniceraceae	10	1	11
Valerianaceae	1		1
Cucurbitaceae	1		1
Campanulaceae	3		3
Lobeliaceae	5		5
Compositae	137	12	149
Total of Dicots	710	110	820
Total of Flowering Plants	905	143	1048
Total of Gymnosperms	9		9
Total of Pteridophytes	33		33
GRAND TOTAL	947	143	1090

THE ECOLOGY OF CERTAIN CRUSTACEANS ON THE BEACHES AT MISAKI, JAPAN, WITH SPECIAL REFERENCE TO MIGRATIONS FROM SEA TO LAND

By A. S. Pearse

Plates 10, 11

The rocky shores at Misaki are of unusual interest to ecologists. Their surfaces are full of holes, crevices, and canals which often contain pools of water and which give shelter to many littoral animals. The migrations of many types from sea to land is actually taking place across these beaches at the present time. During the summer of 1921 the writer worked at the Marine Biological Station of the Imperial University of Tokyo from August 1 to September 6. Dr. Naohide Yatsu, the Director of the Station, and other members of the staff extended every possible courtesy, for which the writer renders grateful thanks. The following persons kindly identified specimens: Dr. M. J. Rathbun, crabs; Dr. Waldo Schmitt, shrimps and hermit crabs; Dr. C. B. Wilson, copepods; J. O. Maloney, isopods; and Dr. H. Boschma, rhizocephalans.

Thirteen species of crustaceans were studied—ten crabs, a porcellanid, and two isopods. The habitats of these are briefly described in the following list:

Brachyura

1. *Sesarma* (*Holometopus*) *haematocheir* (de Haan); holes in cliffs and clay banks on land, especially where there is seepage of fresh water.
2. *Sesarma* (*Parasesarma*) *pictum* (de Haan); tidal zone; often found in holes and under boulders, but runs freely in the open over the rocks.
3. *Sesarma* (*Holometopus*) *dehaani* (Milne-Edwards); holes in the ground in marshes. Specimens of this species were sent to the writer alive through the kindness of the Department of Pathology, Osaka Medical School.

4. *Hemigrapsus sanguineus* (de Haan); under boulders in sheltered situations in tidal zone.
5. *Pachygrapsus crassipes* (Randall); tidal zone where waves beat on exposed rocks.
6. *Leptodius exaratus* (Milne-Edwards); pools near low tide mark.
7. *Goetice depressus* (de Haan); rocky pools from high tide to low tide mark, and beneath boulders on sandy beaches.
8. *Pugettia quadridens* (de Haan); pools containing algae; near low tide mark.
9. *Helice tridens tridens* (de Haan); burrows on muddy beaches.
10. *Scopimera globosa* de Haan; burrows in muddy beaches.

ANOMURA

11. *Petrolisthes japonicus* de Haan; rocky holes from half tide to below tide mark.

ISOPODA

12. *Ligia exotica* (Roux); rocks between tides and above.
13. *Exosphaeroma oregonensis* Dana; under boulders and algae between tides.

All these species were examined carefully for parasites and food. The freezing points for the body fluids of five crabs were determined with a cryoscope.

PARASITES AND COMMENSALS

In examining crabs for parasites the carapace was removed, the gill cavity was searched carefully, the gills were picked off one at a time and examined under a binocular microscope in a small dish of sea water. The enteron was then removed and teased apart with needles under a binocular. At least ten specimens of each species were examined. In the following list the first figure after the name of a parasite indicates the percentage of individuals infested; the second shows the average number of parasites per individual.

Sesarma haematocheir: gill nematodes, 20–0.2; *Cancrincola wilsoni* Pearse, 60–4.8.

S. pictum: intestinal ciliates, 40; gill nematodes, 20–0.2; blood nematodes, 10–0.3; intestinal nematodes, 20–0.5; *Cancrincola wilsoni* Pearse, 100–11.5.

S. dehaani: sarcophagid fly larvae (*Wohlfahrtia* sp.), 20–0.3. Six of the eighteen specimens of this crab which were examined were females and each of the three of these which was carrying eggs had one or two maggots among them. The enterons of none of these crabs was examined.

Hemigrapsus sanguineus: no parasites. One hundred living specimens of this crab were examined for rhizocephalans, but none was found.

Pachygrapsus crassipes: intestinal gregarines, 10; intestinal ciliates, 20; intestinal flagellates, 10; *Saculina* sp., 30–0.3.

Leptodius exaratus: gill nematodes, 10–0.1; intestinal nematodes, 10–0.1.

Goetice depressus: no parasites.

Pugettia quadridens: intestinal flagellates, 7; gill nematodes, 20–0.3; *Amphiascus nanus* Sars, 10–0.08.

Helice tridens tridens: no parasites.

Scopimera globosa: no parasites.

Petrolisthes japonicus: *Probopyrus yatsui* Pearse, 20–0.2.

Ligia exotica: intestinal ciliates, 20–0.5; commensal peritrichs on abdominal appendages, 70–12; gill nematodes, 80–11.6; *Eulaelaps ewingi* Pearse, 80–11.2.

Exosphaeroma oregonensis: intestinal flagellates, 30–0.5; commensal peritrichs on abdominal appendages, 70–23.9; gill nematodes, 10–0.1.

Probably most of the protozoans observed were not parasites but commensals; they were usually few in number. The same is perhaps true of many of the nematodes. Land crabs and isopods apparently have more parasites than aquatic species, but host specificity is such an important factor in all parasitic infestations that it is difficult to generalize. The rhizocephalan, *Saculina* sp., usually attacks only one species of crab, *Pachygrapsus crassipes* Randall, which lives on the waveswept portions of the beach where non-parasitic, sessile barnacles are most abundant. The writer demonstrated by more extensive observations that this crab host is very commonly attacked by the parasitic barnacle, but the other crabs on the same beaches are rarely infested with the parasite. One individual of another species of crab, *Hemigrapsus sanguineus*, was found carrying a saculina on one occasion, but when the writer went out on the beach and examined 100 of these crabs, not a single parasite was found. This species of crab lives under boulders and is like the hole dweller, *Geotice depressus*, and the two burrowers, *Helice tridens* and *Scopimera globosa* in being without

parasites. Dr. C. B. Wilson in a letter states in regard to the copepod, *Amphiascus nanus* Sars, "species of this genus have been found commensal in ascidians, but as far as I know this is the first one from a crab."

The writer's observations make it appear that the crustaceans which live on land or in situations where they are most exposed to the open sea are most likely to be attacked by parasites; and that those which commonly lurk in crannies or burrows are least subject to infestation. The land isopod carries parasitic mites and the land crabs are attacked by parasitic copepods and fly larvae.

Freezing Points of Body Fluids

Five crabs were large enough and were available in sufficient numbers so that determinations were made of the freezing points of body fluids.

TABLE I

Depression of Freezing Point (Δ) of Body Fluids in Five Species of Crabs

	NUMBER OF TESTS	NUMBER OF CRABS	Δ	HABITAT
Sea water Salinity, 33.15	3	25	−2.09	
Sesarma haematocheir	5	25	−1.43	Humid land
Sesarma pictum	5	39	−2.17	Between tides
Hemigrapsus sanguineus	5	34	−2.19	Sheltered places, between tides
Pachygrapsus crassipes	5	38	−2.24	Wave swept shores, between tides
Pugettia quadridens	1	13	−2.27	Pools near low tide

For making such tests crabs were collected in moist cloth bags, brought immediately to the laboratory, and placed in clean glass dishes. Each crab was wiped as dry as possible with a clean cloth, punctured through the carapace in the region of the heart, and squeezed over a funnel so that the body fluids entered the inner cup of the cryoscope. The results are shown in Table I.

There is a graded series. The crabs which live continually in or closely associated with the ocean have the densest body fluids and those which live on land have the rarest fluids. Apparently arthropods, like vertebrates, in becoming adjusted to life on land lose some of the salt content of the blood. This probably means that such animals are developing mechanisms for maintaining the blood at a more or less

constant salinity, regardless of changes in the surrounding medium. This is one of the important steps in the attainment of terrestrial life.

The gills were counted in the same species which had been used for the determination of freezing points of body fluids. Crabs were left in chromic acid over night and carefully studied with the following results: *Sesarma haematocheir*, 16; *S. pictum*, 16; *Hemigrapsus sanguineus*, 16; *Pachygrapsus crassipes*, 18; and *Pugettia quadridens*, 18. There is a slight reduction in the number of gills in the three species of crabs which have the rarest body fluids. These have committed themselves to terrestrial life, but the last two still retain the full number of gills and, though properly littoral, stay always on the edge of the beach nearest the ocean. Schlieper (1929) found that the blood of a freshwater crab in Netherlands had an osmotic pressure which was fairly stable in various solutions and was less than that of the ocean.

FOODS

Satisfactory records of the foods eaten by eleven species of crustaceans were obtained. Estimates by volume were made of all constituents and these are given as percentages in the following list:

Sesarma haematocheir: plants, 100.
S. pictum: plants, 100.
Hemigrapsus sanguineus: arthropods, 25; oligochaetes, 7; polychaetes, 17; algae, 38; unknown, 13.
Pachygrapsus crassipes: crabs, 51; algae, 49.
Leptodius exaratus: crabs, 6.5; snails, 2; algae, 66.5; mud, 19; sand, 6.
Goetice depressus: own eggs, 14.3; sponges, 1.7; algae, 84.
Pugettia quadridens: algae, 100.
Helice tridens tridens: algae, 100.
Scopimera globosa: plants, 50; mud, 50.
Petrolithes japonicus: sponges, 89; algae, 9.5; mud, 1.5.
Ligia exotica: arthropods, 24; plants, 33; mud, 33; unknown, 10.

The two crabs which have most nearly attained land life are strict vegetarians and the land isopod is omnivorous. The crabs which live in the tidal zone are largely vegetarian, but some have become partly carnivorous and two have turned to inert sponges for food. The crab, *Pachygrapsus crassipes*, which eats the greatest percentage of flesh is the agile frequenter of wave-beaten rocks. It is truly a hunter, and not a scavenger or a stolid vegetarian.

SUMMARY

1. Littoral crustaceans which are more or less established as land animals apparently have more parasites than those which have remained strictly marine. Some of the parasites (copepods) have been brought from the ocean and others (mites, fly larvae) have been acquired on land.

2. Littoral crustaceans which are becoming adjusted to land life have less salt in their body fluids and have often lost some of their gills.

3. Though most littoral crustaceans are vegetarians, a few have taken up animal foods to some extent or have become scavengers. At Misaki the two which are most terrestrial are strictly vegetarian and, though speedy, are not as swift as one species, *Pachygrapsus crassipes* (Randall), which has become partly carnivorous and remained next to the sea.

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EXPLANATION OF PLATES 10 AND 11

PLATE 10

Above: The home of the red land crab, *Sesarma haematocheir*.
Below: The rocks at Misaki.

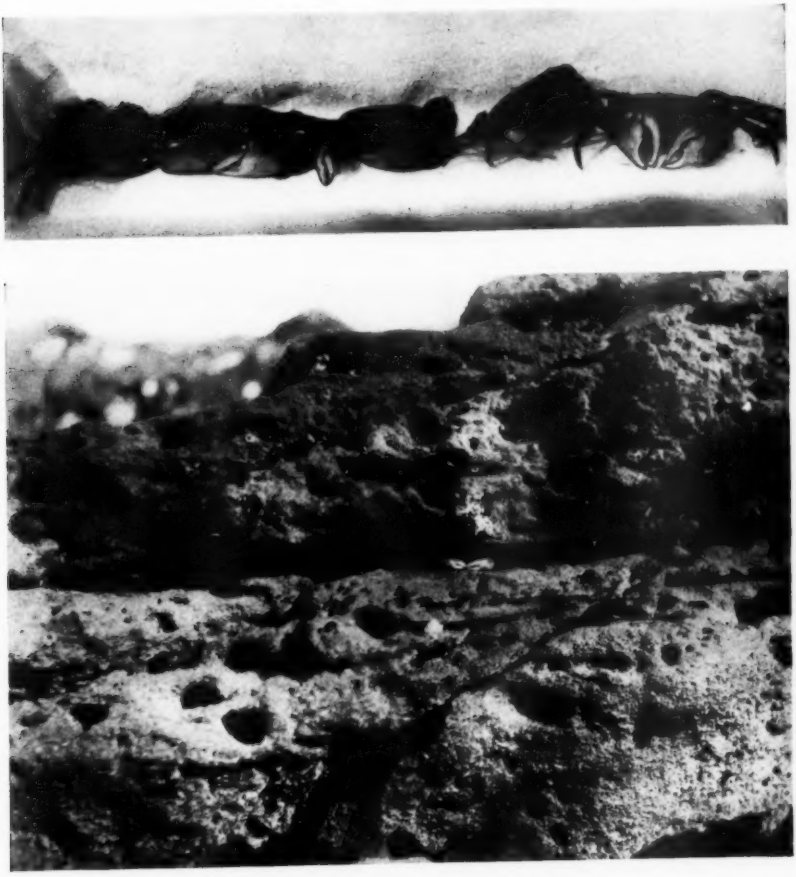
PLATE 11

Above: The five crabs for which the freezing point of the body fluids was determined; from left to right: the spider crab, *Pugettia quadridens; Hemigrapsus sanguineus; Pachygrapsus crassipes; Sesarma pictum;* and the land crab, *Sesarma haematocheir*.

Below: *Pachygrapsus crassipes* Randall in its rock crevice.

PLATE 10

PLATE 11



TWO NEW SPONGES FROM THE CHESAPEAKE BAY

By H. V. Wilson

The U. S. Bureau of Fisheries has been making in recent years under the direction of Professor R. P. Cowles of Johns Hopkins University an ecological survey of Chesapeake Bay. Among the sponges intrusted to me for identification are the two new forms described below.

Suberites paradoxus n.sp.

The upper body of the sponge is a flat continuous lamella about one millimeter thick, perforated here and there by small apertures; from this upper body flattened and very areniferous downgrowths extend, establishing through anastomosis with one another a coarse honeycomb-like structure. The lamellate main body apparently rests upon the sea bottom while the honeycomb-like structure, which may extend 20 mm. or more below the main body, is probably more or less buried in the muddy sand on which the sponge grows. The flattened trabeculae composing the honeycomb-like structure seem at first sight to be made up chiefly, if not entirely, of sand. Sections show however that they are really plates of sponge tissue with abundant sand grains in the interior, the sponge tissue including flagellated chambers, mesenchyme cells that are especially abundant near the surfaces, and numerous spicules scattered irregularly.

The upper, lamellate, body is densely filled with megascleres. At the dermal surface these are arranged radially with the pointed ends outward and not projecting or barely projecting beyond the surface. Below these the spicules are irregularly scattered except that near the basal surface they tend to lie more or less tangentially. Mesenchyme composed of small and closely packed cells is abundant at (near) both dermal and basal surfaces.

The only spicules are tylostyles, smooth, sharp-pointed, slightly curved, with well marked heads. They range from 220μ x 7μ to 350μ x 8μ. The radial spicules at the surface of the upper body average a somewhat smaller size than those in the deeper part of the lamella. The range in the former is about 220μ to 300μ in length, in the latter 280μ to 350μ in length.

Dendy, 1921 p. 147, records a form, *Suberites cruciatus* Dendy var. *depressa* nov., from the Indian Ocean which, like the species described above, takes into its body some of the mineral material on which it rests. Dendy's variety is based on a sponge of thinly incrusting habit which "covers somewhat extensively an irregular mass of calcareous débris which it partially incorporates in its own substance."

The material, fragmentary although showing the character of the form, was taken in Chesapeake Bay by the U. S. Bureau of Fisheries Str. *Fish Hawk* at U. S. B. F. station 8824, 7–8–1920, in beam trawl and mud-bag. The holotype is deposited in the U. S. National Museum, Cat. No. 22064.

Tetilla laminaris George and Wilson, var. *symmetrica*, n. var.

In the type (George and Wilson 1919, p. 142) the body is a vertical lamella rooted by its lower edge. The radial skeletal fibres extend out from a fairly well marked mesial skeleton made up of fibres which pursue in the main a vertical direction.

In the variety here recognized the shape is roughly ellipsoidal, the long axis vertical; a small terminal osculum at the upper end and root-tufts at the lower end. Correlated with this difference in shape from the type is the arrangement of the main skeletal fibres which radiate from an eccentric point situated above the centre of the body. The sponges are pinkish in alcohol and smooth. Little emphasis should, however, be placed on the smoothness, since sections show that most of the spicules of the peripheral radial brushes have been broken off just beyond the surface. The largest specimen is 45 mm. high, greatest transverse diameter 24 mm. The smallest specimen, exclusive of root-tuft, is 24 mm. high, greatest transverse diameter 13 mm.

The megascleres present only differences in size, and not important ones, from those of the type. The sigmas of the two forms do not differ.

The relationship of this variety to *T. gravata* Hyatt (Sollas 1888, p. 46) is probably close. Hyatt's specimens came from Buzzard's Bay. Lendenfeld in his Tierreich synopsis of the Tetraxonia (1903) does not record *T. gravata*.

Three specimens taken in Chesapeake Bay at U. S. B. F. Station 8982 by U. S. B. F. Str. *Fish Hawk* in beam trawl, 4–2–1921. Holotype and the two co-types deposited in U. S. National Museum, Cat. No. 22065.

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A CHECK LIST OF THE COMMON MOSSES OF DURHAM, N. C., AND VICINITY

By H. L. Blomquist

In a scientific study of the plant covering of any region, all groups of plants should receive consideration. This seems to be seldom done, however, especially in North America where most of the floras written are confined to the vascular plants. The result of this is that in any study of plants in which a knowledge of the kind of plant or plant materials used is necessary—which is true of most studies—the lower forms are seldom used or taken into account. This holds true even for courses in general botany and ecology in which, above all others, it seems reasonable that all kinds of plants should be dealt with to some extent at least. The presentation of this list of mosses from this section is done with the hope that it will eventually lead to a better knowledge of the kinds of plants which occur in our surroundings and that these may some day be used in attempts to gain further knowledge of plant life.

The knowledge of the bryophyte flora of North Carolina is very incomplete. The studies which have been made have been confined largely to the western part of the state. It seemed, therefore, that it would be of interest and value to make a study of these plants of the lower piedmont, especially as several of our higher institutions of learning in the state are located in this section.

The list which follows is more or less incomplete, but it is intended that it should include only those species which were collected within a period of not over a year. In fact, most of them were collected from the first part of February to June, 1930. Not over thirty trips were made in collecting, which fact is the principal basis for the expression, "common mosses." It is also realized that simply a list of species is not of much value when not accompanied by a practical key, but a key is in preparation and will be published in the near future.

The writer has collected nearly all of the specimens used in this study and identified or attempted to identify them. Duplicates were then sent to recognized authorities who confirmed or corrected the identifications made and identified those which were not identified.

Grateful acknowledgment is due to A. J. Grout, George B. Kaiser, and especially to A. LeRoy Andrews, who kindly did this work.

The systematic arrangement is based on Grout's *Mosses* (1903). Other works consulted are: Evans & Nichols, *The Brophytes of Connecticut* (1908), Grout, *Mosses with a Hand Lens*, third edition (1924), Jennings, *A Manual of Mosses of Western Pennsylvania* (1913), and Roth, *Die europäischen Laubmoose* (1905).

ORDER SPHAGNALES

FAMILY SPHAGNACEAE

1. Sphagnum subsecundum Nees. Common in moist meadows. Not found in fruit.
2. Sphagnum cuspidatum Ehr. In bogs, often submerged. Not collected in fruit but with sex organs in February–March.
3. Sphagnum compactum D C. On soil in boggy situations. Sex organs in February–March. Not collected when fruiting.

ORDER BRYALES

SUBORDER I. NEMATODONTEAE

FAMILY POLYTRICHACEAE

4. Catharinea undulata (L.) W. & M. (*Athricum undulatum* Beauv.). Edges of rocky streams. Not as common as the next species. Autumn.
5. Catharinea angustata Briel. (*Athricum angustatum* Br. & Sch.). Our most common moss. Sandy soil, especially after having been disturbed; along streams and around bases of uprooted tree trunks. Early autumn; sex organs in spring.
6. Polytrichum commune L. Largest of our acrocarpous mosses. Common in boggy lowlands. Spring.
7. Polytrichum ohioense R. & C. (*P. formosum* of some authors). Occurs on higher and drier land than *P. commune*. Spring.
8. Polytrichum juniperinum Willd. Rather rare. Sandy clay soil. Not found fruiting.
9. Pogonatum brevicaule (Brid.) Beauv. [*P. tenue* (Menz.) E. Grey]. Common on bare clay banks such as dams and roads. The common green coloring on clay banks is the persistent protonema of this moss. Late autumn.
10. Pogonatum brachyphyllum (Mx.) Beauv. Sandy and loamy soil. In some places associated with *Polytrichum commune*. Spring.

FAMILY BUXBAUMIACEAE

11. Webera sessilis (Schmid.) Lindb. (*Diphyssium foliosum* Mohr.). Moist, shaded, humus banks. Late spring.

SUBORDER II. ARTHRODONTEAE

GROUP I. APLOLEPIDEAE

FAMILY FISSIDENTACEAE

12. Fissidens cristatus Wils. (*F. decipiens* De Not). On moist soil and stones in shaded places, especially around springs. Not found fruiting.
13. Fissidens taxifolius (L). Hedw. On soil near streams. Not found fruiting.
14. Fissidens osmundoides (Swtz.) Hedw. One of our largest species of Fissidens. In various places but often on rocks and soil in or on the edge of streams. Not found fruiting.
15. Fissidens incurvus Schwaegr. (*F. minutulum* Sull.). Most commonly on rocks in streams. Not found fruiting.

FAMILY DICRANACEAE

16. Bruchia Sullivantii Aust. Common in sandy clayey fields, associated with *Sphaerocarpus texanus* and *Pleuridium subulatum*. April.
17. Pleuridium subulatum (L). Rabenh. A common minute moss on clayey fields. February–March.
18. Ditrichum pallidum (Schreb.) Hampe. (*Leptotrichium pallidum* Hampe.). Dry sandy soil in open woods. Conspicuous by its pale yellow sporophytes. Late spring.
19. Ditrichum tortile (Schrad.) Hampe. (*Leptotrichium tortile* C. Mull.). Moist banks of recently disturbed soil, especially on edges of fields. April–May.
20. Ceratodon purpureus (L.) Brid. Not as common here as farther north. Hard barren soil; hence, around abandoned buildings, paths and roads. March–April.
21. Dicranella heteromalla (L.) Schimp. (*Dicranum heteromallum* Hedw.). Rocky banks. Autumn.
22. Dicranella rufescens (Dicks.) Schimp. Rather rare. Found on brick wall associated with *Tortula muralis*. Early autumn.
23. Dicranum scoparium (L.) Hedw. Common on various substrate but especially in open woods. Early summer.

24. Dicranum condensatum L. & J. Dry sandy upland woods, associated with other species of Dicranum. Early summer.
25. Dicranum undulatum Ehrh. Resembles *D. scoparium* but is larger and associated with it. Summer.
26. Dicranum fulvum Hook. (*V. interruptum* Brid.). Common on rocks in the vicinity of streams. Summer and autumn.
27. Leucobryum glaucum (L.) Schimp. (*L. vulgare* Hampe.). In moist woods and banks. Autumn and winter.
28. Leucobryum albidum (Brid.) Lindb. In rather dry sandy soil in woods. Winter.

FAMILY GRIMMIACEAE

29. Hedwigia albicans (Web.) Lindb. (*H. ciliata* Ehr.). Common on rocks, especially in the vicinity of streams. Spring.
30. Ptychomitrium incurvum (Schwaegr.) Sull. [*Glyphomitrium incurvum* (Schwaegr.) Sull.] Commonly on rocks associated with Hedwigia and Grimmia. February.
31. Grimmia pennsylvanica Schwaegr. Common on rocks. Late autumn.
32. Grimmia apocarpa (L.) Hedw. On rocks. Not as common as *G. pennsylvanica*. Late autumn.
33. Grimmia Olneyi Sulliv. On rocks in and near streams. March.

FAMILY EPHEMERACEAE

34. Ephemerum serratum (Schreb.) Hampe. On clayey banks near stream, associated with Physcomitrella and Notothylas. October.
35. Acaulon triquetrum (Spruce) C. Mull. Clay fields. December-January.
36. Physcomitrella patens (Hedw.) B. & S. Moist clay banks and on pots in greenhouses. October.

FAMILY TORTULACEAE

37. Weisia viridula (L.) Hedw. Dry and moist soil, woods and old fields. Common. February-March.
38. Weisia viridula var. australis Aust. (*W. longiseta*). Old fields. Late autumn.
39. Barbula unguiculata (Huds.) Hedw. On damp earth, especially around buildings and on walls. Winter.
40. Tortella caespitosa (Schwaegr.) Limpr. (*Barbula caespitosa* Schwaegr.) Common at base of trees on soil. April.

41. Tortula muralis (L.) Hedw. (*Barbula muralis* Timm.) Exclusively on brick walls. March.
42. Tortula pagorum (Wilde) DeNot. On trees and rock walls in cities. Not found in fruit. Apparently all plants are archegonial plants.[1] Antheridial plants have been found in western Austria.

GROUP 2. DIPLOLEPIDEAE

Sub-Group Acrocarpae

FAMILY ORTHOTRICACEAE

43. Drummondia clavellata Hook. On trees, especially in the vicinity of streams. March.
44. Orthotrichum strangulatum Sulliv. On trees, especially common in cities. March.
45. Orthotrichum ohioense S. & L. Same habitat as the preceding species. These two species do not seem to be easily distinguished. March.

FAMILY FUNARIACEAE

46. Physcomitrium turbinatum (Mx.) Brid. (*P. pyriforme* of some authors). Common in moist fields, on lawns and along roads. Often associated with *Funaria hygrometrica*. March.
47. Funaria hygrometrica (L.) Sibth. Common, especially after burns and where wood ashes are found. March.

FAMILY AULACOMNIACEAE

48. Aulacomnium heterostichum (Hedw.) B. & S. Moist, shaded, humous banks near streams. Associated with *Bartramia pomiformis* and certain species of Fissidens. March.
49. Aulacomnium palustre Schwaegr. In moist boggy places, associated with *Sphagnum* spp. April.

FAMILY BARTRAMIACEAE

50. Philonotis marchica Sulliv. In moist ground especially where some water is standing and on dripping ledges in streams. Not collected in fruit.
51. Bartramia pomiformis (L.) Hedw. Common on shaded steep banks along streams. March.

[1] The Bryologist, May, 1930.

FAMILY BRYACEAE

52. Leptobryum pyriforme (L.) Wils. Moist shaded places, especially at base of foundations of buildings. May-June.
53. Bryum affine (Bruch.) Lindb. Damp shaded rocks and walls. May-June.
54. Bryum atropurpureum Wahlenb. Dry sandy soil. April-May.
55. Bryum argenteum L. Sandy fields, waste places, and between stones and bricks in walks and sidewalks. Spring.
56. Rhodobryum roseum (Weis.) (*Bryum roseum* Shreb.) On rotten logs, base of trees and rocks in moist shaded situations. Not found fruiting altho both antheridial and archegonial plants have been collected in winter.
57. Mnium cuspidatum (L.) Leyss (*M. sylvaticum* Lindb.). Woods and lawns in moist shaded places. April-May.
58. Mnium affine Bland. Common on edges of streams. Spring.
59. Mnium stellare Reich. Base of trees in moist places. Rather rare. Not collected in fruit.
60. Mnium punctatum L. Edges of streams on moist soil and rocks. Not collected in fruit.

Sub-Group Pleurocarpae

FAMILY LESKEACEAE

61. Thuidium delicatulum (L.) Mitt. (*Hypnum delicatulum* L.). On rotten logs, on stones and earth. Spring.
62. Thuidium paludosum (Sulliv.) R. & H. [*Hypnum paludosum* Sulliv. *Elodium paludosum* (Sulliv.) Loeske]. In moist boggy places associated with *Sphagnum subsecundum* and *Aulacomnium palustre*. Not found fruiting.
63. Leskea obscura Hedw. Common on bark of trees. Not found fruiting.
64. Anomodon minor (P. Beauv.) Fuern. (*A. obtusifolium* B. & S.) On lower trunk of trees near streams. Winter.
65. Anomodon attenuatus (Schreb.) Huebn. On rocks and base of trees in the vicinity of streams. Not collected in fruit.
66. Anomodon rostratus (Hedw.) Schimp. Common on soil at base of trees, wet rocks and cliffs. Autumn.
67. Thelia hirtella (Hedw.) Sulliv. Common on base of trees. Autumn.
68. Thelia asprella (Schimp.) Sulliv. Habitat similar to *T. hirtella* but in more swampy situations. Autumn.

FAMILY HYPNACEAE

69. Brachythecium salebrosum (Hoffm.) B. & S. (*Hypnum salebrosum* Hoffm.). Common on earth, stones and roots of trees. Often on lawns. Not collected in fruit.
70. Brachythecium acuminatum (Hedw.) Kindb. (*Hypnum acuminatum* Beauv.). Base of trees in shaded places. Autumn.
71. Brachythecium rivulare (Bruch.) B. & S. (*Hypnum rivulare* Bruch.). On sticks and rocks in springs and quiet streams. October.
72. Brachythecium oxycladon (Brid.) J. & S. (*Hypnum laetum* Brid. *B. laetum* B. & S.)
73. Brachythecium plumosum (Sw.) B. & S. (*Hypnum plumosum* Sw.) On rocks in and near streams and other moist places. Not found fruiting.
74. Eurynchium hians (Hedw.) J. & S. (*Hypnum hians* Hedw.) Commonly on soil along streams. Not found in fruit.
75. Eurynchium serrulatum (Hedw.) Kindb. (*Hypnum serrulatum* Hedw.). In moist shaded places on humus soil. Autumn.
76. Cirriphyllum Boscii (Schwaegr.) Grout (*Hypnum boscii* J. & S.) Common on moist banks along streams associated with *Bartramia* and *Aulacomnium heterostichum*. Late autumn.
77. Homalothecium subcapillatum (Hedw.) Sulliv. [*Homalotheciella subcapillata* (Hedw.) Card.] At base of trees near streams. Autumn.
78. Climacium americanum Brid. Moist banks, along streams and in boggy situations. Autumn.
79. Porotrichium alleghaniense (C. M.) Grout. On rocks in streams especially where water trickles. Not found fruiting.
80. Campyllium chrysophyllum (Brid.) Bryhn. [*Hypnum chrysophyllum* Brid., *Chrysohypnum chrysophyllum* (Brid.) Loesk.]. Over earth and stones in moist places. Late spring.
81. Campyllium hispidulum (Brid.) Mitt. [*Hypnum hispidulum* Brid., *Chrysohypnum hispidulum* (Brid.) G. Roth.]. Over rotten wood, roots and ground in moist shaded places. Late spring.
82. Amblystegium varium (Hedw.) Lindb. On moist ground near springs. Spring.
83. Amblystegium orthocladon (P. B.) Kindb. On rocks in slow streams. April.

84. Amblystegium fluviatile (Sw.) B. & S. (*Hypnum fluviatile* Sw.). On rocks in small streams. Spring.
85. Sciaromium Lescurii (Sulliv.) Broth. On rocks and sticks in streams, especially in waterfalls. Spring.
86. Hypnum molluscum Hedw. [*Ctenidium molluscum* (Hedw.) Mitt.]. Edges of streams. Not found fruiting.
87. Hypnum curvifolium Hedw. [*Stereodon curvifolius* (Hedw.) E. G. B.]. In cool and moist places over rocks, rotten wood, and ground in the vicinity of streams. Spring.
88. Hypnum patientiae Lindb.[*Stereodon Lindbergii* (Mitt.) Warnst.]. In swamps and along streams near water. Not collected in fruit.
89. Hypnum reptile Mx. [*Stereodon reptilis* (Mx.) Mitt.]. Bases of trees, on stones and decaying wood in shaded places. Spring.
90. Hypnum pratense Koch [*Stereodon pratensis* (Koch) E. G. G.]. Swampy meadows. Not found in fruit.
91. Raphidostegium adnatum (Mx.) B. & S. (*Hypnum microcarpon* L. & J., *Sematophyllum adnatum* E. G. B.). On bark of living trees. Late autumn.
92. Raphidostegium carolinianum (C. M.) J. & S. [*Sematophyllum carolinianum* (C. Mull.) E. G. B.]. On wet rocks near streams. Summer.
93. Plageothecium micans (Sw.) Paris. On rotten wood, such as stumps and branches in moist places. Spring.
94. Plagiothecium denticulatum (L.) B. & S. (*Hypnum denticulatum* L.). On ground, rotten wood and stones in moist shaded places. Summer.
95. Amblystegiella adnata (Hedw.) Nichols (*Hypnum adnatum* Hedw.) *Amblystegium adnatum* Aust.). On bark of trees and on stones. Autumn.
96. Entodon seductrix (Hedw.) C. M. (*Cylindrothecium seductrix* Sulliv.). At base of trees and on rotten wood and soil. Late autumn.
97. Entodon cladorrhizans (Hedw.) C. M. (*Cylindrothecium cladorrhizans* Schimp.). At base and on roots of trees and on rocks. Autumn.
98. Platygyrium repens (Brid.) B. & S. On bank of living or fallen tree trunks. Autumn.
99. Pylasia Schimperi R. & C. (*P. intricata* B. & S.) On bark of trees. Autumn.

FAMILY FABRONIACEAE

100. Fabronia octoblepharis (Schleich.) Schwaegr. On bark of trees considerably above ground. One of our smallest mosses. Early spring.
101. Clasmatodon parvulus (Hampe) Sulliv. On bark of trees, especially in the vicinity of streams. Spring.
102. Clasmatodon parvulus var. rupestris. Same habitat as *C. parvulus*. Spring.
103. Anacamptodon splachnoides (Froelich) Brid. Moist cavities in decaying wood, especially in knot holes in living trees. Spring.

FAMILY LEUCODONTACEAE

104. Leucodon julaceus (Hedw.) Sulliv. On bark of trees. February-March.
105. Leucodon brachypus Brid. Habitat same as for *L. julaceus*. February-March.
106. Cryphea glomerata R. & S. On bark of trees, associated with the Leucodons.

FAMILY FONTINALACEAE

107. Fontinalis novae-Anglia Sulliv. On rocks, floating in streams. Early summer.

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OBSERVATIONS AND EXPERIMENTS RELATING TO THE BACTERIAL PUSTULE DISEASE OF SOYBEAN[1]

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The bacterial pustule disease of soybean was first described by Hedges (2) in 1922. In 1924 Wolf (5) published a descriptive account of the disease and its causal agent, and in the same year there appeared an account of further studies of the same disease by Miss Hedges (3). Since the publication of these papers the writer has had occasion to make numerous observations and has conducted certain experimental tests with this disease. The results of some of these experiments will be presented in the following pages.

THE PUSTULE AS A DIAGNOSTIC CHARACTER

In making field observations considerable difficulty is encountered at times in distinguishing the lesions of bacterial pustule (*Bacterium phaseoli sojense* Hedges) (2) (3) from those of the bacterial blight disease (*Bact. glycineum* Coerper and *Bact. sojae* Wolf) (1) (4). The separation is made with less difficulty if one is observing the disease in its earliest stages of development, for, at that time, the bacterial blight lesions are characterized by a translucent or water-soaked appearance not associated with lesions of bacterial pustule. Later, when full development of the lesions has been attained, the watersoaked appearance of bacterial blight is no longer sufficiently pronounced to be of much value as a criterion of separation of this disease from bacterial pustule.

Another character of considerable value in recognition of bacterial pustule is the presence of minute intumescences or pustules on the diseased spots. These pustules occur on either or both leaf surfaces as definite but minute elevations barely visible to the naked eye of the average person. They soon rupture and dry down leaving the broken tissue remnants at the center of the lesion.

In the published accounts of bacterial pustule, the emphasis placed

[1] Published with the approval of the Director of Research as paper Number 30 of the Journal Series.

on the presence of pustular elevations as an important diagnostic character leaves the impression that a pustule is invariably produced as a result of infection by the causal organism of this disease. The natural inference is that a lesion without evidences of pustular development must be ascribed to causes other than the bacterial pustule disease. That this deduction is not necessarily correct and that the bacterial pustule disease may be represented by leaf spots entirely devoid of pustular development is indicated by the writer's experience in the several seasons just past.

While examining plants in some seed treatment plots, leaf spots were found which possessed many of the characters of lesions of the pustule spot disease but which showed no evidence of pustular development. These were brought to the laboratory and examined with a dissecting microscope. Careful examination revealed no evidence that a pustule had ever formed on these spots. There were no remnants of pustules which had dried down, nor was the epidermal layer broken in any place such as is clearly visible microscopically when pustular remnants fall away. Microscopic examination revealed abundant bacteria and no fungal hyphae in these spots, and, in order to determine if they were caused by the organism of bacterial pustule or by some other bacterial parasite, a number of the spots were used for making isolations. The several lesions selected for this purpose were angled, reddish brown to almost black, surrounded by a narrow halo, possessed diameters of 1.5 to 2.5 mm. and showed no evidence of pustular remnants. Usually several similar non-pustulate lesions were present on the same leaf along with lesions showing pustular remnants, but occasionally only non-pustulate lesions were found on a leaf.

In making the isolations an excised portion of the leaf bearing only one lesion was washed under the tap while being gently rubbed to facilitate wetting and to remove as many surface bacteria as possible. The diseased tissue was then immersed for 15 seconds in 1–1000 solution of mercuric chloride, subsequently washed in sterile water, and finally macerated in a large drop of sterile water. In some instances the isolations were made by the poured plate method, in others by spreading a loopful of the bacterial suspension on the surface of beef agar plates.

White and yellow colonies were obtained on all the plates, yellow colonies predominating in most instances. Both white and yellow colonies were transferred to culture tubes and used for inoculation of plants in the greenhouse. In no case was infection obtained on the plants inoculated with the white organisms. On the other hand, the

yellow colonies produced leaf spots with definite and well developed pustules in every way typical of the bacterial pustule disease. The lesions were angular, brown to reddish brown, surrounded by a narrow yellow-green halo, and possessed definite pustular elevations. In agar tube and plate cultures these yellow organisms had the same macroscopic appearance as other cultures of *Bacterium phaseoli sojense* obtained from young lesions bearing typical pustules.

No lesions devoid of pustules were obtained as a result of the greenhouse inoculations with the bacteria isolated from the non-pustulate lesions. However, in another test in the greenhouse in which several varieties had been inoculated with a strain of *Bacterium phaseoli sojense* isolated from a pustulate lesion, both pustulate and non-pustulate lesions were produced on leaves of the Mammoth Brown variety. Except for the presence or absence of the pustule, the two types of lesions were identical in appearance. In regard to number, the pustulate lesions on the Mammoth Brown variety greatly exceeded the non-pustulate. No non-pustulate lesions were found on any of several other varieties examined in this test. The non-pustulate lesions from which the isolations recounted above were made occurred on the variety Tar Heel Black.

The yellow bacteria obtained from the non-pustulate lesions were undoubtedly a strain of *Bacterium phaseoli sojense*. Just why this bacterium should produce pustulate lesions normally and non-pustulate lesions at certain times or under certain conditions is not clear. The situation is akin to that reported by Miss Hedges as the result of inoculating lima bean with *Bacterium phaseoli sojense* isolated from pustulate lesions on soybean. Miss Hedges obtained infection on the lima bean leaves but no pustules were formed. Except for absence of hypertrophy leading to pustular development, the early symptoms on lima bean, namely, the appearance of pale green spots with red centers, were much like those on soybean. However, if the lesions on lima bean developed beyond the stage noted above, they became water soaked and unlike later stages of lesions on soybeans.

According to the writer's observations with the soybean pustule organism in greenhouse inoculation tests, infection occurs only on young leaves. As an explanation of the occasional occurrence of non-pustulate lesions on soybeans, the following suggestion may be offered: Two or more strains of the bacterial pustule organism are sometimes present in a field. The toxic by-products of the strain or strains most commonly observed are of such potency as to stimulate pustule formation under

all conditions in which infection occurs. Other strains give rise to pustules only when infection occurs on young leaves; but, if infection is delayed until the leaf has attained a more advanced stage of maturity, the mesophyll cells, having become less sensitive to stimuli or more susceptible to poisons, do not first respond to the toxic by-products of the bacterial action by increase in size and number but become necrotic at once. The lesions increase in size normally and develop the usual coloration but are devoid of pustules.

The pustule is unquestionably a useful character in diagnosis of bacterial pustule of soybean. It is produced in the great majority of infections, but its absence from lesions is not conclusive evidence that they do not represent the bacterial pustule disease. In making field examinations, other symptoms such as size, shape, color, and halo characters should be given due consideration.

RELATION OF TEMPERATURE AND OF AGE OF LEAF TO INFECTION

In studying the occurrence of the bacterial pustule disease in the field, it has been the writer's experience that the disease is not much in evidence before the hottest days of midsummer, although soybean plants have been in foliage for some two or three months previous. At this time of hot weather there occurs a striking and pronounced development of the disease if rainfall conditions are at all favorable for spread of the causal organism. Similarly favorable rainfall earlier in the season has not been followed, in the writer's experience, by a similarly pronounced development of the disease. Moreover, inoculations made in the greenhouse at various times have given discordant results and have suggested that the pronounced development in the field during hot weather might be explained by the assumption that air temperature was an important factor determining whether or not infection of soybean leaves followed inoculation with the bacterial pustule organism. In order to obtain more information bearing directly on this point, two experiments were undertaken in the greenhouse.

In the first of these tests, two pots each containing 4 young soybean plants of the Biloxi variety were selected. Each plant bore 2 unifoliate and 2 trifoliate leaves at the time of inoculation. The plants were atomized with a heavy suspension of a 12 day old culture of *Bacterium phaseoli sojense*, covered with bell jars, and shaded with brown paper. Pot 1 was placed in a glass-sided incubator which was set to run at 30°C. but occasionally went up to 33°C. during the hottest part of the day. Pot 2 was placed on a greenhouse bench where the temperature

ran at 20°C. or below, for the greater portion of the 24 hour period but rose up to 25°C. in the hottest part of the day. The bell jars and paper shades were removed after 4 days. The results of this test are given in Table I.

TABLE I

EFFECT OF TEMPERATURE AND MATURITY OF LEAF ON INFECTION OF SOYBEAN LEAVES BY BACTERIUM PHASEOLI VAR. SOJENSE

EXPERIMENT	POT NUMBER	TEMPERATURE DURING TEST		RESULTS AFTER LAPSE OF TIME INDICATED	
		Day	Night	11 days	13 days
		°C.	°C.		
I	1	30–33	30	Many lesions. Pustules already erupted	Many lesions. All on the 2 trifoliate leaves open at time of inoculation. None on unifoliate (oldest) leaves
	2	Up to 25	20 or below	Very few visible infections. Pustules not yet evident	Very few lesions. Pustules present
				7 days	23 days
II	1	30–33	30	Total of 364 lesions. All lesions per plant on topmost leaf open at time of inoculation	Nearly all lesions per plant on topmost leaf open at time of inoculation; very few on next (older) and none on the two oldest leaves
	2	22 up to 30	22	Total of 123 lesions. All lesions per plant on topmost (youngest) leaf open at time of inoculation	Nearly all lesions per plant on topmost leaf open at time of inoculation; very few inconspicuous lesions on next (older) and none on the two oldest leaves
	3	Up to 28	15 to 20	No lesions	No lesions

The second experiment was similar to the first except that a series of 3 pots, each containing 5 plants, was used. Each plant carried 4 trifoliate leaves open at the time of making the inoculation. Pot 1 was kept in a glass-sided incubator which ran at 30°C. but occasionally went up to 33°C. during the hottest part of the day. Pot 2 was in a

similar incubator which was set to run at 22°C. but which went up to 30°C. in the hottest part of the day. Pot 3 stood on the greenhouse bench. Here the temperature ranged between 15 and 20°C. at night and went up to 28°C. during the hottest part of the day, while the plants were covered with the bell jar. After removal of the bell jar the air temperature in the vicinity of these plants did not go above 25°C. The results of this test are also shown in Table I.

While it was impossible under the conditions of these tests to limit the temperature fluctuations of the inoculated plants to narrow ranges, the results, as recorded in Table I, indicate roughly the temperatures at which one may expect infection of the bacterial pustule disease to occur. In Experiment I, very few lesions and, in Experiment II, none at all developed on the plants held within the range of temperatures fluctuating between 15 and 28°C. Moreover, the few infections that did occur on the plants held at this low temperature level developed more slowly than on plants maintained at higher temperatures. Infection occurred and lesions developed most abundantly on the plants maintained continuously at 30 to 33°C. while an intermediate number of lesions developed on the plants held at the intermediate range fluctuating between 22 and 30°C. The temperatures to which the plants of Pot 1 were subjected in each test are roughly comparable to those which occur during the hottest days of summer in July and August while the temperatures of Pots 2 and 3 are more comparable to those which occur in May and June. Thus it appears that the results of these experiments bearing on the relation of air temperature to those properties of host and parasite which determine infection by the soybean bacterial pustule organism are consistent with field experience and serve, in part at least, to explain the occurrence of the disease in its most severe form in the hottest part of summer.

That the susceptibility of the soybean leaf to infection by *Bacterium phaseoli sojense* is lessened by increase in age or advance in stage of maturity is likewise indicated by the results of Experiments I and II. In both experiments nearly all the lesions resulting from the artificial inoculations occurred on the youngest leaf open at the time, comparatively few appearing on the second (older) and none on the third (oldest) leaf. Another test may be cited as an illustration of this correlation of age of leaf and susceptibility to infection. A pot of soybean plants of the Herman variety was sprayed with a heavy suspension of *Bacterium phaseoli sojense* on July 17. Each plant had 4 trifoliate leaves open at the time of making this inoculation. Twelve days later, on July 29,

when the results were recorded, each plant had 5 expanded trifoliate leaves, the youngest having opened since the plants were inoculated. At this time numerous infections had occurred on each plant on the second leaf from the top, the youngest open on the date of the inoculation. The three older leaves on each plant carried very few lesions and none were present on the young leaf which had opened since the date of inoculation. The results of these three experiments are in conformity with similar observations made in other inoculation trials not here reported. In no inoculation test in which this point was noted has infection occurred on a leaf older than the third back from the leaf most recently unfolded at the time of the inoculation, and the great majority of infections have always occurred on the youngest leaf open at that time.

OVERWINTERING ON DISEASED LEAVES

A knowledge of the method of overwintering of the organism causing the bacterial pustule disease is of considerable value to the soybean grower. On October 15, 1927, a quantity of diseased leaves were picked up from the ground beneath soybean plants which were just maturing their seed. These leaves were stored in the laboratory and thus were kept dry during the entire time of storage. On July 16, 1928, a number of these diseased leaves was pulverised in the dry condition, then moistened freely with water. After 3 hours, during which time the wet mass of leaves was stirred occasionally, a portion of the water was squeezed out and used for inoculating young soybean plants. More water was then added to the mass of wet leaves and the whole left to stand for a longer time with the expectation that a larger number of bacteria might be obtained in suspension. At the end of 18 hours the water was again drained off and used for inoculation of other plants. In each case, the inoculation was made by swabbing the young leaves of Herman soybeans with a wad of absorbent cotton wet with the suspension obtained from the diseased leaves. The inoculated plants were covered with bell jars for 3 days. At the end of 13 days the results shown in Table II were recorded.

The results of this experiment show that the bacterial pustule disease may overwinter on dry diseased leaves and that the causal organism *Bacterium phaseoli sojense* is capable of remaining alive for not less than 9 months in such material. A total of 19 lesions developed on 12 of the 131 leaflets inoculated in pots 2, 3, and 4. The highest proportion of infected to inoculated leaflets was 8 to 42. At the time of making

this as well as the following test, no account was taken of the fact that infection from a given inoculation is confined very largely to the youngest or topmost leaves on the plant. Very probably at least one-half of the leaflets inoculated in these two tests had already reached the stage of maturity at which they were no longer susceptible to infection. If this be true, the above mentioned ratio of 8 to 42 and the other lesser ratios to be derived from the data of Table II are too low to represent a true index of the number of viable bacteria in the overwintered material.

The absence of uninoculated check plants does not invalidate the results of this test. The lesions produced on the inoculated plants resembled bacterial pustule in all their characters. Haloes and pustules were present and bacteria were abundant in the diseased tissues. More-

TABLE II

RESULTS OBTAINED BY INOCULATING HERMAN SOYBEAN PLANTS WITH A SUSPENSION PREPARED FROM OVERWINTERED DRY DISEASED LEAVES

HOURS LEAVES WERE SOAKED	POT NUMBER	NUMBER OF LEAFLETS		TOTAL NUMBER OF LESIONS
		Inoculated	Infected	
3	1	Not recorded	None	None
	2	51	3	4
18	3	38	1	1
	4	42	8	14

over, the writer is satisfied that the infection did not come from other diseased plants growing in the greenhouse at the time, for this disease does not spread under the usual greenhouse conditions. The writer has grown hundreds of soybean plants in the greenhouse and has kept pots of diseased and healthy plants standing side by side for 4 weeks, but has yet to find a single bacterial pustule developing on plants which had not been artificially inoculated. Watering was usually done by pouring the liquid directly on the soil.

Although *Bacterium phaseoli sojense* is able to live for 9 months in dry leaves, there is some question regarding its ability to over-winter in leaves exposed to weathering and decay. Certain data bearing on this point were secured from the following experiment. On April 11, 1928, a large handful of diseased leaves were plucked from plants which had been artificially inoculated several times in the greenhouse. These

leaves were placed in a cheese-cloth bag and deposited on the ground in a shady nook where they never received direct rays of the sun and where they remained moist continuously. On July 12, 1928, three months from the time they were placed on the ground, the leaves were used for inoculating growing soybean plants of the Herman variety. At this time the leaves and the bag surrounding them were much decayed, readily falling apart on little disturbance. This decayed leaf material was stirred in a quantity of water for a period of 30 minutes. The mixture was allowed to settle for a few minutes and then the supernatant liquid was rubbed onto leaves with a swab of absorbent cotton. The results obtained at the end of 13 days are shown in Table III.

The results recorded in Table III show that a total of 9 leaflets became infected out of 88 inoculated. Here, as in the test with dry leaves,

TABLE III

RESULTS OBTAINED 13 DAYS AFTER INOCULATING SOYBEAN LEAVES WITH A SUSPENSION OF DECAYING DISEASED LEAVES

POT NUMBER	NUMBER OF LEAFLETS		TOTAL NUMBER OF LESIONS
	Inoculated	Infected	
1	58	3	7
2	30	6	21
Total.....	88	9	28

no account was taken of the relation between age of leaf and susceptibility to infection, and, although the inoculated plants were young, probably at least one-half the leaves inoculated were no longer susceptible to infection. Had only the youngest and most susceptible leaves been inoculated, the incidence of disease very probably would have been higher than that recorded in the table.

It is apparent that *Bacterium phaseoli sojense* may remain alive for at least 3 months in decaying diseased leaves. Since the cool temperatures of the months December, January, February, and March reduce the processes promoting decay of plant refuses to a rate considerably less than that which obtains during the warmer months of late spring and early summer, the period during which this test was under way, considerable support is given the thought that the pustule organism may survive the winter not only in dry leaf material, but also in plant refuse subjected to the processes of decay.

CONCLUSIONS

Pustules are not invariably produced on lesions resulting from infection of soybean leaves by the causal agent of the bacterial pustule disease. Temperature and maturity of leaf are significant factors in the complex of influences determining the amount of disease which results from inoculation of susceptible varieties. This disease is perpetuated by over-wintering of the causal agent in dry diseased leaves and perhaps also in moist decaying leaves.

SUMMARY

1. *Bacterium phaseoli sojense*, the causal agent of the bacterial pustule disease of soybean, was isolated from lesions devoid of any evidence of pustular development. It is believed that these lesions were caused by this bacterium and that under certain conditions intumescence does not follow infection by this organism. The absence of pustules from lesions is not conclusive evidence that they do not represent the bacterial pustule disease.

2. Infections were most numerous and lesions developed most rapidly when the inoculated plants were kept at relatively high temperatures. A greater number of lesions occurred on plants held continuously at 30 to 33°C. than on plants kept at a temperature which fluctuated between 22°C. and 30°C. Very few lesions developed on inoculated plants when the air temperature fluctuated between 15°C. at night and 25°C. during the hottest part of the day. The amount of disease which follows inoculation with the organism which causes bacterial pustule is dependent in part on the temperature which prevails during the infection and incubation period.

3. Following artificial inoculation the greatest number of lesions per leaf was always found on the youngest leaves of the plant open at the time of inoculation. Susceptibility to the bacterial pustule disease diminishes rapidly with increasing maturity of leaf.

4. The organism causing bacterial pustule of soybean is capable of remaining alive for at least three months in decaying leaves and nine months on dry leaves. This is ample time to carry the disease from one crop to that of the succeeding season.

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POWDERY MILDEW OF SOYBEAN[1]

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Soybean plants growing in the greenhouse at North Carolina State College of Agriculture in the winter of 1927–1928 became diseased with powdery mildew. Although phytopathological literature contains many references to powdery mildew on leguminous plants, the writer was unable to find any reference to powdery mildew on soybean in the literature then at hand. It is the purpose of this article to record certain observations made at that time relative to the occurrence of the disease on soybean.

This disease was first observed by the writer on January 6, 1928.[2] At that time, it appeared in the form of leaf spots having a dirty grayish aspect or a color only slightly duller than the normal green of the surrounding leaf tissue. This diseased appearance was obvious only on the upper side of the infected leaves, there being at that time no change of color of the lower leaf surface. Five days later, on January 11, the diseased areas had assumed a white powdery appearance which was accompanied by a reddening of the underlying tissues. A microscopic examination revealed the presence of a mycelium with conidiophores and conidia of the powdery mildew type. This fungus growth was confined to the upper side of the diseased areas, the lower surface remaining free. The reddening of the infected leaf tissues varied from pale pink to deep vinaceous and was most clearly distinguishable on

[1] Published with approval of the Director of Research as paper No. 45 of the Journal Series.

[2] Somewhat more than a year later than this date, the writer learned, through correspondence with Dr. R. J. Haskell, that the Plant Disease Survey, Bureau of Plant Industry, United States Department of Agriculture had one record of powdery mildew on soybean in the United States. The exact date of this report is missing from the survey records, but Dr. F. A. Wolf, who made the report from Raleigh, North Carolina, gives it as his opinion that the observation was made in 1921. At that time the disease occurred on soybeans and also on cowpeas growing in the greenhouse. Only the conidial stage was observed, but since the disease occurred in the same house at the same time, the fungi on the two kinds of plants were assumed to be the same species.

the lower leaf surfaces because of the absence of any obscuring layer of mycelium and spores. The diseased soybean plants were 10 to 12 inches tall and bore 5 trifoliate leaves and a few half grown pods. Infection occurred only on leaflets; stems, pods, and petioles remaining free. Leaflets of all ages except the very youngest showed the disease.

At the time of the occurrence of this powdery mildew disease on soybean plants, garden beans were growing just across the walk way in the same greenhouse. Powdery mildew had been present on the garden beans for several weeks previous to its appearance on soybeans. This situation makes it appear probable that the soybeans became infected by means of conidia carried from the diseased garden beans and that the disease on the two kinds of plants was due to the same species of fungus. There was, however, a very obvious difference in behavior of the disease on the two kinds of plants. On garden bean, the mildew spread rapidly and soon almost completely covered leaves, pods and young stems. On soybean the fungus did not spread rapidly over the leaves but occurred in somewhat localized areas which seldom exceeded 1 cm. in diameter. There was also a pronounced difference in the amount of mycelium and conidia produced per unit area on the two kinds of plants. On garden bean, the surface of affected parts became very white with a relatively heavy layer of mycelium and conidia. No such profuse development occurred on soybean even on the largest diseased areas, and the white, powdery, mildewey aspect was much less pronounced because of the sparse development of the pathogen.

In order to determine if the fungi on the two suscepts were morphologically alike, a search was made for perithecia, but none could be found on either the garden bean or the soybean. Microscopic examinations of the conidia from the two kinds of plants showed them to be alike in respect to shape, both being elliptical with slightly flattened ends. Likewise, both had the same conspicuously foamy protoplasmic structure. Fig. 1 is a camera lucida drawing of conidia produced on the garden bean. These conidia were taken from the garden bean plants used in the artificial inoculation test described below. Conidia from soybean leaves are shown in Fig. 2. These conidia were taken from a naturally infected boybean leaf after it had lain 5 days in a moist chamber. The drawings of Fig. 1 and 2 would indicate a considerable difference in size between conidia on garden bean and soybean. However, a small variation in the scale at which the two drawings were made accounts for part of this apparent difference and the remainder may well be attributed to the dissimilar conditions, as indicated above, under

which the conidia were produced. When these drawings were made the infected soybean plants had matured and it was no longer possible to obtain enough turgid conidia from soybean to make measurements of

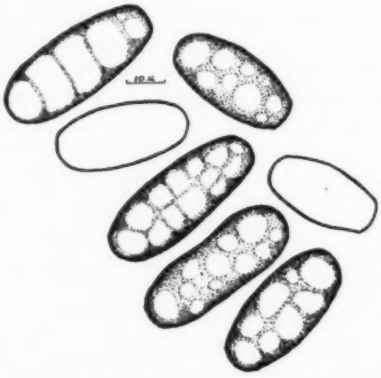

FIG. 1. CAMERA LUCIDA DRAWINGS OF CONIDIA OF POWDERY MILDEW ON GARDEN BEAN

Taken from plants artificially inoculated and kept in a glass sided inoculation chamber during development of the disease.

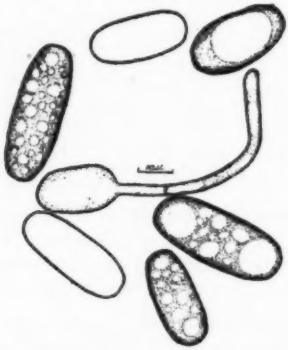

FIG. 2. CAMERA LUCIDA DRAWING OF CONIDIA OF POWDERY MILDEW ON SOYBEAN

Taken from a naturally infected soybean leaf after it had lain 5 days in a moist chamber.

any considerable number. However, turgid conidia were still available on garden bean and measurements of 52 of these showed a size range of 26–52 microns by 16–23 microns with a mean of 36.5μ by 19.4μ. It seems probable that approximately the same sizes would have been found for conidia on soybean had an equal number from that host been available for measurement.

In an attempt to perpetuate the mildew on soybean for further study, the following inoculation test was made. Three pots of soil were planted to stringless green pod garden bean and three pots to the Morse

FIG. 3. SOYBEAN LEAVES SHOWING AREAS OF REDDENED TISSUE INFECTED WITH THE FUNGUS OF POWDERY MILDEW

Photograph taken after the leaves had become somewhat moribund and had lost much of their green color.

variety of soybean. These were kept in a glass sided inoculation chamber. When the soybean and garden bean plants had developed two trifoliate leaves apiece, they were inoculated with conidia from garden bean. The inoculation was made by shaking diseased garden bean plants bearing a heavy load of spores over the young soybean and garden bean plants. The young plants were atomized with water immediately before and several times following inoculation in order to make certain that moisture conditions should not be unfavorable for spore germination on the leaves. This inoculation was made on April 23 and repeated on April 30.

On May 4 mildew was observed to be present on the plants of garden bean. On May 9 the mildew was growing vigorously on garden bean and killing many of the leaves. Mycelium and conidia had developed abundantly on both leaves and stems. Fig. 1 was drawn from conidia taken from these plants at this time. By May 15 all the bean plants had been defoliated and killed by the mildew fungus.

No mildew appeared at any time on the soybean plants. Because of reduced light in the inoculation chamber, they had grown tall and spindling and each plant had produced several leaves, but no sign of infection was evident.

The fungus *Erysiphe polygoni* is generally considered to be the cause of powdery mildew of garden bean (*Phaseolus vulgaris*). The circumstances accompanying the occurrence of the powdery mildew on soybean as described above, lead the writer to assume that the conidia found on the soybean leaves represent the oidium stage of *Erysiphe polygoni*. The presence of mildew on garden bean in the same greenhouse for several weeks previous to its occurrence on soybean, and the morphological similarity of conidia from the two kinds of suscepts support this view.

Erysiphe polygoni was reported by von Wahl[3] as a parasite on *Soja maxima* in Europe in 1921. He gave no descriptive account of the disease but merely reported its occurrence with the name of the causal fungus. The writer is not informed as to whether the plant designated *Soja maxima* by von Wahl is the cultivated soybean of America to which the names *Glycine hispida* Maxim. and *Soja max* (L) Piper are commonly applied.

An explanation of the isolated occurrence of powdery mildew on soybean grown in the greenhouse and of the failure to produce the disease in the above described artificial inoculation test in which conditions seemingly were made very favorable for infection may be sought in the phenomena of mutation and physiological specialization. The existence of specialized physiological strains has been shown for *polygoni*, *graminis*, and other species of *Erysiphe*. *Erysiphe polygoni* occurs on a number of legumes, both cultivated and wild, and presumably the garden bean strain is specialized for that particular suscept species. Mutation in the mildew on the garden bean plants growing in the greenhouse may have produced a relatively few spores of a strain genetically and physiologically conditioned for parasitism of soybean. Further

[3] Schädlinge an der Sojabohne. Zeitschr. f. Pflanzenkr. **31**: 94–196. 1921.

propagation of this particular physiological strain of *E. pologyni* was cut off by maturity and subsequent destruction of the infected, greenhouse grown, soybean plants.

The powdery mildew disease of soybean occurred only on the Morse variety. Plants of Biloxi, Otootan and Herman were present in the greenhouse at the time the disease was observed on Morse, and had the same opportunity to become inoculated, but no mildew occurred on these varieties. Apparently Morse is the least resistant of the four varieties under observation. The disease has not been observed in the field

POLYCODIUM

By W. W. Ashe

Polycodium Raf.[1]

Shrubs, stems often subterranean. Leaves alternate, entire with 1 to 3 pairs of sessile basal glands. Flowers 5-lobed, not articulate with the pedicels which are slightly dilated upward, appearing with the leaves in bracted racemes; calyx lobes persistent, erect, sometimes accrescent; corolla white, pinkish or purplish, campanulate, open in bud; stamens 10, anthers exserted, clawed, prolonged into tubes with lacerated terminal openings. Berry with many pitted seed, 5-but seemingly 10-celled by intrusion of placentae, green, yellow, red, purple or black, often glaucous, ripening in midsummer or later.

Polycodium has long been one of the most neglected genera among southern woody plants. However, Mohr, Greene and Small have made notable contributions towards its elucidation and many of the species now seem to be fairly well understood. Mohr,[2] who was the pioneer, unfortunately limited his investigations to Alabama. He was well acquainted with the three forms which he described as they grew, but did not make comparisons needed for clearly separating them from related forms outside of the region of his intimate study. Greene[3] called attention to Nuttall's long neglected *Polycodium Floridanum*, which was described by Nuttall[4] as *Pricrococcus Floridanus*, a species with foliaceous bracts and small flowers. Greene[5] likewise described from Florida three conspicuously pubescent species which also have foliaceous bracts and small flowers, characters which are restricted to a group of species confined to the region from South Carolina to Florida. Four species were thus described in the group with foliaceous bracts. Each of these is pubescent, though one of them (*Polycodium Floridanum*) is only scantily so.

[1] *Polycodium* Raf. in Am. Mag. May, 266. 1818.
Picrococcus Nutt. in Pr. Am. Phil. Soc. N. S., **8**: 262. 1843.
Vaccinium (in part) L. Syst. Ed. 1. 1735.
[2] Tor. Bull. **24**: 25. 1897. Contr. U. S. Natl. Herb. **6**: 658. 1901.
[3] Pitt. **3**: 324. 1898.
[4] Trans. Am. Phil. Soc. II. **8**: 262. 1843.
[5] Pitt. **3**: 249. 1897. Leaflets **2**: 226. 1912.

The flowers of *Polycodium* offer few distinctive specific characters due in part to the manner of development, those of any one species seeming to show a considerable range of size dependent upon the stage at which examined. *Polycodium sericeum* has exceptionally large flowers and two groups of allied species have small flowers (*Floridana* and *glandulosa*). The fruit upon an individual plant likewise varies in size dependent upon its relative position in the raceme, the terminal berry being the largest and the lower progressively smaller. The fruit of a number of species has distinctive color, but color of fruit in other species is a character of doubtful value. It is a character, however, which is often entirely lost in drying and should invariably be noted at the time of collection. The presence of stalked glands associated with the pubescence of the inflorescence or upon the wood of the season seems to characterize one group of species (*sericea*) and to be a specific character in one species (*glandulosum*) of another group. The size and shape of the leaves are distinctive in several species. Foliaceous floral bracts are the rule in two groups of species (*Floridana* and *glandulosa*) and in one species (*arcuatum*) of another group, but reduced bracts occur in all of the species of which the bracts are characteristically foliaceous, and usually associated with enlarged bracts upon the same plant. *Polycodium kunthianum* has bracteolate pedicels. In *P. Floridanum* and in other species this character is sporadic. No species seems to be evergreen, but *P. multiflorum* is semi-evergreen.

GROUPS OF SPECIES OF POLYCODIUM

Glandulosa. Bracts as a rule foliaceous, broadly ovate or obovate; corolla short, lobes obtusely triangular; calyx glabrous, lobes triangular, short; fruit black, skin thin, glossy (beneath a heavy bloom); leaves densely glaucous, glabrous on both faces or in *glandulosum* often sparingly pubescent: *glandulosum, ashei.*

Floridana. Bracts as a rule foliaceous, broadly ovate or oblong; corolla short, lobes obtusely triangular; calyx lobes triangular, short (oblong in *quercinum* and sometimes in *concoloratum*); fruit black or red-black, skin thin, glossy (usually beneath a bloom); leaves pubescent, sometimes sparingly, on both faces: *Floridanum,* and vars. *caesium, revolutum* and *molle; oliganthum, quercinum, concoloratum.*

Multiflora. Bracts rarely foliaceous; leaves, inflorescence and twigs pubescent; corolla deeply divided, lobes rounded; fruit purple-black; calyx lobes oblong, accrescent; inflorescence not glandular; *multiflorum* and variety; *lautum.*

Sericea. Bracts rarely foliaceous (only in *arcuatum*); corolla deeply divided, lobes rounded; calyx pubescent, lobes mostly oblong, usually accrescent; fruit red (orange-colored in a form of *sericeum*) to dark purple (rarely with a bloom), skin usually thick; inflorescence often glandular: *sericeum, depressum, langloisii, arcuatum, kunthianum.*

Melanocarpa. Bracts not foliaceous; corolla deeply divided, lobes rounded; calyx glabrous, lobes mostly elongated-triangular, rarely or not accrescent; fruit purplish black or black, skin usually thin, glossy (often with a bloom); inflorescence glandular pubescent only in *candicans: melanocarpum, bellum, candicans.*

Staminea. Bracts not foliaceous; corolla deeply divided, lobes rounded; calyx glabrous except in varieties of *interius* and *stamineum*, lobes triangular, not accrescent; fruit white to red or purple, skin usually thick, dull (often with a bloom); foliage glabrous or pubescent; glandular pubescence wanting except in a variety of *interius: interius* and varieties; *stamineum, neglectum, parvum, arenicola.*

Walter (Flora Carol. 139. 1788) was the first to separate *Vaccinium stamineum* and *V. arboreum* from the related species; but he regarded *V. stamineum* as representing the true *Vaccinium* while he placed the other forms known to him in a new genus.

KEY TO SPECIES

A—Flowers small, seldom 5 mm. long (in 4 sometimes 6 mm.), lobes of corolla very short, obtusely triangular; bracts as a rule foliaceous; fruit glossy, black or red-black, often glaucous. (Southeastern, chiefly Floridian)

B—Leaves glabrous or sparingly pubescent (No. 1) on both faces, usually densely glaucous below; bracts mostly ovate or obovate, often obtuse or rounded at apex; twigs glabrous and glaucous, or glandular pubescent

C—Inflorescence and twigs glandular pubescent; bracts ovate or broadly ovate.....(1) *P. glandulosum*

C—Inflorescence and twigs glabrous; bracts of an obovate type (2) *P. ashei*

B—Leaves and bracts usually glaucous beneath (see var. of 3); bracts of an ovate type; leaves pointed at apex, more or less pubescent on both faces, twigs never glandular-pubescent; fruit usually with bloom

C—Leaves quite pubescent, often reticulated or revolute; calyx glabrous or pubescent, lobes triangular; fruit with or without bloom; bracts broadly ovate, rounded at apex. High longleaf pine lands and hammocks.....(3) varieties of *P. Floridanum*

C—Leaves sparingly pubescent on both faces, often nearly glabrous, ciliate; ovate or narrower, not conspicuously reticulated, sometimes revolute

D—Leaves 3 to 5 (5.5) cm. long; bracts broadly ovate, mostly rounded at apex; fruit 9 to 12 mm. thick, black. High longleaf pine lands (3) *P. Floridanum*

D—Leaves often revolute, 2.5 to 4 cm. long; bracts ovate, acute; fruit 6 to 10 mm. thick. Scrub lands.....(4) *P. oliganthum*

B—Leaves and bracts green or yellowish beneath, usually of an oblong or obovate type; pedicels rarely as long as thickness of fruit

C—Leaves acute or obtuse at apex, finely reticulated, pubescence limited to midrib and cilia on margin, calyx lobes mostly triangular (5) *P. concoloratum*

C—Leaves obtuse or rounded at apex, not reticulated, pubescent on both faces; calyx lobes oblong.....(6) *P. quercinum*

A—Flowers small or large, 4–7 mm. long, but corolla deeply divided with rounded lobes; bracts rarely foliaceous (sometimes in 7 and 12); fruit variously colored

B—Calyx usually pubescent, glabrous in 8, lobes narrow or oblong, rarely narrowly triangular, prominent, usually accrescent, foliage pubescent on both faces; fruit not glaucous, usually (9) dark red or black (13 is Mexican; 9 alone of others extends beyond the Gulf States)

C—Fruit 8–10 mm. thick, black or dark red, glossy; lower part of inflorescence never glandular pubescent; foliage green on both faces or pale beneath

D—Leaves pale beneath; calyx pubescent

Calyx lobes not glandular.....(7) *P. multiflorum*

Calyx lobes glandular.....(7a) *P.m. uniquum*

D—leaves green beneath; calyx galbrous.....(8) *P. lautum*

C—Fruit red to dark purple, orange in a var. of 9; usually dull, the larger more than 12 mm. thick, inflorescence, at least lower bracts, usually glandular pubescent or glandular ciliate; leaves yellow green beneath except var. of 9.

D—Pubescence velvety, glands often copious;

Plant more than 4 dm. tall; leaves of ovate type; flowers 7 mm. long.....(9) *P. sericeum*

Plant more than 4 dm. tall; leaves narrower..(9a) *P. s. elongatum*

Plant less than 3 dm. tall; leaves oblong type; flowers 5–6 mm. long.....(10) *P. depressum*

D—Pubescence not velvety, glands never copious, rarely wanting; pedicels not bracteolate

Plant dwarf, under 4 dm. tall; leaves under 5 cm. long; bracts not foliaceous.....(10a) *P. depressum minus*

Plant 5–8 dm. tall; leaves over 5 cm. long; bracts rounded at apex, never foliaceous.....(11) *P. langloisii*

Plant 10 dm. or more tall; leaves over 5 cm. long; bracts often foliaceous, apex usually acute.....(12) *P. arcuatum*

D—Pubescence not velvety, pedicels bracteolate; fruit unknown (Mexican).....(13) *P. kunthianum*

B—Calyx glabrous (sometimes glandular pubescent in 16) lobes triangular or if oblong not prominent, ciliate, fruit black or nearly so, glossy, often glaucous; leaves not conspicuously reticulated.

C—Leaves scantily pubescent or merely glaucescent beneath, no glandular pubescence

D—Leaves glabrous and glaucescent, ovate lanceolate or broader, not ciliate.....(14) *P. melanocarpum*

D—Leaves sparingly pubescent and bright green beneath, lanceolate; ciliate like the lance-linear bracts.....(15) *P. bellum*

C—Leaves pale and velvety beneath or white glaucous, glandular pubescence often present.

D—Leaves pale velvety beneath, shoots usually with some glandular pubescence.....(16) *P. candicans*

D—Leaves glaucous and sparingly pubescent beneath; glands often wanting.....(16a) *P. candicans glaucescens*

B—Calyx usually glabrous (see 17 and 20) lobes short triangular, (oblong in var. of 20) not prominent; fruit white, yellow or red, mostly dull; glandular hairs absent except in *P. interius subglandulosum;* leaves often conspicuously reticulated

C—Essentially glabrous or with bracts and sometimes leaves ciliate in *neglectum,* or inflorescence glandular in *P. interius subglandulosum* (17b)

D—Leaves yellowish green on both faces; finely reticulated, veins prominent; fruit dark red; lower bracts often ciliate (17) *P. interius*

D—Leaves pale beneath, ovate to oblong, more than 5 cm. long; fruit thick-skinned, not glossy, yellow or pink, plant more than 3 dm. high (eastern).....(18) *P. neglectum*

D—Leaves more than 5 cm. long, ovate to oblong white-glaucous beneath, fruit red; plant more than 8 dm. high (18a) *P. n. harbisonii*

D—Leaves less than 6 cm. long, lanceolate or broader, pale or glaucous beneath, fruit dark red; plant less than 3 dm. high (19) *P. parvum*

C—Leaves pubescent and yellow-green beneath reticulated, veins prominent, fruit nearly black, shining.....(17a) *P. interius commune*

C—Leaves pubescent and pale or whitened beneath

D—Not prominently reticulated; more than 4 dm. high; fruit dull, skin thick

Flowers small, 4–5 mm. long; fruit red, yellow or white; calyx glabrous.....(20) *P. stamineum* and vars

Flowers 5–6 mm. long; fruit dark red; calyx often pubescent (20a) *P. s. austro-montanum*

D—Leaves finely reticulated; fruit dark red; plant less than 2 dm. high.....(21) *P. arenicola*

Note. In the case of recognized species, reference is made only to specimens which indicate limits of distribution.

1. **Polycodium glandulosum** sp. nov.

Commonly single-stemmed, 1.4 to 2 m. high but much branched. Twigs pubescent with short gland-tipped hairs. Leaves ovate to elliptic ovate, 2.8 to 7 cm. long, 1.6 to 3.4 cm. wide, width about $\frac{2}{3}$ of length, subcordate or rounded at the narrowed or sometimes broad base, often obtuse or rounded at apex, ciliate, otherwise glabrous except for slight pubescence above and sometimes below on midrib, densely glaucous below, neither reticulated nor revolute. Flowers appearing in March and April are 4.5 to 6 mm. long to the end of the shallowly notched corolla; calyx lobes short or narrowly triangular, usually glabrous; bracts foliaceous, seldom reduced, mostly broadly ovate, acute or rounded at apex, subcordate at base, ciliate, often shorter than the pedicels; fruit 7–11 mm. thick, glabrous, sometimes glaucous, reddish black and glossy when ripe late in July; rachis and slender pedicels pubescent with scattered wide-spreading gland-tipped hairs.

Alaqua Creek, Walton Co., Fla., southeastward, to Old Town, Dixie County, Fla. Very common in small hammocks, along the edges of swamps, and sometimes in pine flatwoods in Wakulla county, Florida, *W. W. A.*, May 17, 1928 (type for flowers); July 28, 1928 (type for fruit). A local species but on account of its glandular pubescent twigs one of the most distinct.

2. **Polycodium ashei** Harbison in Mid. Nat. **22**: 179. 1930.

Glabrous and densely glaucous throughout; 5–7 dm. tall, forming clumps, but sparingly branched. The obovate often retuse bracts are distinctive. Leaves rarely exceed 4 cm. long by 1.6 cm. wide. South Carolina, near Columbia, southwest to Hildreath, Suwannee County, in north peninsular Florida, mostly in longleaf pine flatwoods. Type: *W. W. A.*, near Jesup, Wayne County, Ga., Mch., 1927 and Aug., 1926. Very common in Wayne County, Ga., and adjacent region; rare and local in Florida.

3. **Polycodium Floridanum** Greene, Pitt. **3**: 324. 1898.

Picrococcus Floridanus Nutt. Tr. Am. Ph. Soc., N.S., **8**: 262. 1843.

Nuttall's description of his plant is as follows:

"Leaves ovate or cordate-ovate, acute, at length smooth, peduncles axillary, 1-flowered, subbracteolate, corolla but little longer than the 5-cleft calyx; dorsal awns of the stamina minute. Vaccinium Floridanum Herb. Schweinitz. Habitat Florida (Mr. Cooper). I have seen only a single branch in which the flowers appear truly axillary.

The calyx is unusually large; corolla small and contracted; the leaves about 2 inches long and more than an inch wide."

The type specimen is apparently lost. Von Schweinitz'[6] correspondent was William Cooper, for many years an officer of the New York Lyceum of Natural History. It seems probable that the Cooper specimen came from Florida between 1830 and 1840 since Nuttall's paper was read in December 1841. Settlement and largely travel to Florida during this period were limited to the hilly, well drained region with loamy, mostly reddish subsoils and well suited to cotton culture. Tallahassee had recently been located within this hilly region. Its site was selected as the Capital in the middle of the state. Pensacola was "west Florida." St. Augustine and the immediately adjacent region on the Atlantic coast was called "east Florida" by Nuttall in referring to a specimen collected by Mr. Ware in the same article in which he describes *Picrococcus Floridanus*. The Cooper specimen "from Florida" probably came from this Tallahassee region.

There is referred to *P. Floridanum* a shrub of which the known distribution is from Hildreath, Suwannee County, Fla., (*W. W. A.*, May 15, 1929), and Lake Arbuckle, Polk Co., Fla. (*W. W. A.*, May 25, 1928), northeast to McRae, Telfair Co., Ga. (*W. W. A.*, May 28, 1929), and westward to Ochlockonee, Leon Co., Fla. (*Kurz* and *Ashe*, May 17, 1928) and nortwest to Cuthbert, Randolph Co., Ga. (Apl. 28, 1930). It is a plant of well drained rolling sandy lands. Two of these collections show bracteolate pedicels and while this cannot be regarded as a character it indicates, as noted by Nuttall in the Cooper specimen, that it is of occurrence in this species. A characterization of this species as it is understood is as follows:

Leaves 3 to 5.5 cm. long of a prevailingly ovate type, base subcordate, apex acute, not reticulated and rarely revolute, above finely pubescent on midrib and veins, below glaucous, pubescent on midrib, rarely on veins, margin ciliate; twigs glabrate or pubescent, usually glaucous; calyx glabrous, lobes broadly triangular, tips pubescent, fully one-half the length of the small corolla with its short lobes; fruit, ripening May to July, 7–11 mm. thick, black and glossy, often beneath a light bloom; pedicels 8 to 16 mm. long; bracts varying from ovate to broadly ovate prevailingly foliaceous, rounded or acute at apex and often cordate at

[6] Although there are frequent references in the Torrey-Schweinitz correspondence (1819 to 1833) to Cooper, there is in it no mention by von Schweinitz of Cooper having within this period given him any Florida plants.

base. A shrub 6–12 dm. high of low hammocks or sandy longleaf pine woods approaching hammock (hardwood) sites.

No single specimen of this species which I have seen agrees entirely with Nuttall's description. The larger leaves have about the dimensions given by Nuttall. The leaves, however, do not become "at length smooth" which implies pubescence only while young but they invariably retain some of the scant pubescence. Otherwise there is general agreement, and no other known Florida plant agrees so well. The leaves of *P. glandulosum* conform as to size, but the glandular pubescence could scarcely have been overlooked.

3a. **P. Floridanum caesium** c. nov.

Vaccinium caesium Greene, Pitt. **3**: 249. 1897.

All stages of pubescence of leaves connect *P. Floridanum* with this very abundant and pubescent variety, the calyx and fruit of which are glabrous and glaucous. Type: Nash, No. 573, Eustis, Lake Co., Fla. May 1–15, 1894 (Notre Dame Univ.). Some plants, especially late in the season, bear strongly revolute leaves; others less so. The extreme revolute form with calyx glabrous or glabrate is the following.

3b. **P. Floridanum revolutum** c. nov.

Vaccinium revolutum Greene., Pitt. **3**: 250. 1897.

Type: *Nash* No. 53, Eustis, Lake Co., Fla. Mch. 12–31, 1894 (Notre Dame Univ.).

3c. **P. Floridanum molle** var. nov.

Calyx pubescent. *W. W. A.* Cuthbert, Randolph Co., Ga., Apl. 28, 1930.

Polycodium Floridanum and its varieties hybridize with *P. glandulosum* and *P. ashei.*

4. **Polycodium oliganthum** Greene, Leaflets, Bot. Obs., **2**: 226. 1912.

Plants 1 to 1.5 m. high, twigs pubescent filiform; leaves small, 3 to 4 (5) cm. long, ovate, acute, blue green and obscurely pubescent above, densely glaucous and sparingly pubescent beneath, sometimes ciliate, rarely revolute, not reticulated; calyx glabrous, divisions triangular, fruit small, 6 to 9 mm. thick, black beneath a bloom, maturing May to July; bracts ovate or broadly ovate, acute, rounded at apex; pedicels barely 1 cm. long.

Growing with liveoaks, *Hicoria Floridana*, and *Pinus clausa* in the "scrub" from Lemon City to St. Petersburg, Fla. Very common in Marion County. Type specimen (No. 7264 *S. M. Tracy*, Lemon City, Fla., May 23, 1901[7]) is at the University of Notre Dame, Indiana.

5. **Polycodium concoloratum** sp. nov.

Forming patches with underground stems, the branches 2 to 5 dm. high, twigs slender, matted pubescent. Leaves narrowly ovate or obovate, 3 to 4.2 cm. long, glabrous on both faces except midrib, ciliate, thick, finely reticulated; bracts foliaceous, often broad and cordate at base, and usually rounded at apex, similar to leaves in pubescence. Calyx usually glabrous, the lobes short triangular, rarely elongated, with pubescent tips; pedicels pubescent, much shorter than the bracts, seldom 1 cm. long. High longleaf pine lands, Seminole County, Fla. (type *W. W. A.* near Sanford) and along west coast. St. Leo, Pasco County, *H. O'Neil*, Mch. 24, 1927 (Herb. W. W. A.).

6. **Polycodium quercinum** Ashe in Tor. Bull. **54:** 580. 1927.

The yellow-green elliptical leaves of sterile shoots, rounded at each end are distinctive; 7 to 12 dm. high. Known only from Marion County, Fla.

Type: *W. W. A.* Hammocks, Lynne, Marion County, Fla., June 10, 1925.

7. **Polycodium multiflorum** sp. nov.

Stems often clustered, 1.5–2.3 m. high. Leaves semi-evergreen, ample, 4 to 7 cm. long, of an ovate or narrower type, gradually acute, prevailingly with a broad rounded or narrowed subcordate base, pubescent on both faces, glaucescent, pale or infrequently green beneath, rarely revolute, not reticulated. Bracts oblong or oblong-ovate, usually much reduced, sometimes foliaceous; corolla with rather long rounded or acutish lobes; calyx hirsute, seldom glabrate, often with serrulate, elongated lobes, erect or with tips recurved and eventually coloring red on the fruit; length of peduncle usually exceeding the thickness of the fruit; fruit 8 to 10 mm. thick, sparingly pubescent, black or red-black, glossy, ripening July to September.

West Florida hammocks, where very common in Okaloosa, Santa Rosa, and Walton Counties. March 24, 1927, between Hollyhead and Camp Walton (type for flowers); near Hollyhead, Aug. 26, 1927 (type

[7] In original description "Lemon Bay" and "1906."

for fruit); Valparaiso, June 6, 1925; East Bay, May 8, 1929; Pensacola, April 29, 1923; Oct. 14, 1923; Sept. 10, 1928; Negrohead Bayou, Nov. 7, 1924; June 7, 1929; Oct. 23, 1923; Mossyhead, July 1924; July 1925; Pippin Point, Oct. 26, 1923; Chattahoochee, Nov. 1, 1924—all *W. W. A.*

7a. **P. multiflorum** var. **uniquum** var. nov.

Differs from the type in the elongated lobes of the calyx being glandular.

8. **Polycodium lautum** sp. nov.

One to 1.6 m. high. Twigs pubescent, with short matted hairs. Leaves ovate-lanceolate to oblanceolate, sometimes broader; 4 to 6 cm. long by 1.8–2.7 cm. wide, rounded or narrowed at base; acute or acuminate, short pubescent above, soft pubescent and green beneath, not revolute. Flowers, appearing in April and May are 4.5 to 6 mm. long to the end of the acutish corolla lobes; calyx glabrous, except the ciliate elongated triangular to oblong lobes; bracts mostly oblong; acute, usually rounded, sometimes foliaceous, often shorter than the usually about 1 cm.-long pedicels. Fruit 8–10 mm. thick, reddish black, without bloom, glossy, ripening June and July. Rolling sandy lands. Low Station, Pensacola, Escambia County, Florida (*W. W. A.* April 29, 1923). East of Holmes Valley, Washington County, Florida (*W. W. A.*, June 6, 1929), type.

9. **Polycodium sericeum** C. B. Robinson in Tor. Bull. **39**: 559. 1912.

Vaccinium melanocarpum Rob. and Fern. in Gr. Man. Ed. 7, 639. 1908.

Polycodium melanocarpum Small, Fl. S. E. U. S. 894. 1903.

Not *V. melanocarpum* Kearney in Tor. Bull. **24**: 570. 1897.

Vaccinium melanocarpum sericeum Mohr, Pl. Life Ala. 658. 1901.

Although of limited range this species is one of the best marked of the genus. In its typical form, as shown by many specimens Mohr collected, it has large ovate, ovate-elliptical or elliptical leaves, the larger 6 to 8 cm. long by 3 to 3.5 cm. wide, pubescent, as also the bracts, on the midrib and often the blade above and yellow-green and soft pubescent beneath, ciliate, often with gland-tipped hairs intermixed; inflorescence and often fruit and calyx as well glandular pubescent; flowers with elongated and rounded corolla lobes, the largest in the genus, are 8 to 10 mm. long to the ends of the stamens; bracts reduced, ovate or elliptic rarely as long as the 1.5 cm.-long pedicels; fruit ripening in July, dark red or purplish red, dull, 10 to 14 mm. thick.

Dry hills in oak and *Pinus echinata* woods; customarily 6 to 14 cm. high. Perry County, Ala. (*W. W. A.*), northward to Lawrence County, Ala., east to Augusta, Ga., (*W. W. A.*, Apl. 12, 1923) and Lutz Ferry, S. C., (*W. W. A.* Apr. 12, 1923), south to Chattahoochee, Fla. Most abundant in the mountains of northern Alabama where as in parts of Lawrence andWinston counties it is the only species or occurs associated only with *P. interius subglandulosum* Ashe.

Type: in Mohr herbarium, Univ. of Alabama, is from Ashland[8] (Clay County) Ala., but in the Plant Life of Alabama (l. c.) the type locality is given as "Rocky wooded hills, near Springville, St. Clair County, Ala."

The species passes into the following varieties and form:

9a. **P. sericeum** var. **elongatum** var. nov.

This variety has small lanceolate leaves but is otherwise like the type. Coosa County, Ala. (*W. W. A.*, July 1926).

P. sericeum forma **chrysocarpon** f. nov., with bright orange-colored fruit, was found growing with this variety.

9b. **P. sericeum** var. **eburneum** var. nov.

Differs from the type in having the ample leaves glaucous as well as pubescent beneath.

10. **Polycodium depressum** Small in Torreya **28:** 5. 1928.

This but little branched, dwarf plant is confined to sandy long leaf pine woods and is distributed from western Florida (Small) to Louisiana. From *P. arenicola*, likewise a dwarf species, it is separated by having elongated calyx lobes; and from *sericeum* by having a narrower leaf-form and dwarf habit.

Type: Silverhill, Baldwin County, Ala., in flower only, Small, Mosier, and Matthaus (N. Y. Bot. Garden). *W. W. A.*, Silverhill, Ala.; Poplarville, Miss.; near Kisatchie, La., all 1929.

The species passes into the following variety:

10a. **P. depressum** var. **minus** var. nov.

The pubescence of the variety is not always velvety, and glandular hairs are absent or not abundant. Type: *W. W. A.*, Rapides Parish,

[8] It is possible that Ashland is an error and that Asheville (St. Clair County) was intended since one sheet has Ashland crossed out and Asheville written above by Mohr.

La., May and June, 1929; July, 1930. Eastward to Auburn, Lee County, Ala. (*G. L. Fick* and *W. W. A.*, May 5, 1930.)

11. **Polycodium langloisii** Greene, Leaflets, Bot. Obs. **2**: 226. 1912.

Ashe in Charleston Mus. Quart. **1**: 32. 1925. This species occurs from Meridian, Mississippi (*W. W. A.*) through southern Louisiana extending as far north as Natchitoches Parish (*Dormon* and *Ashe*, May and July, 1928) to Hardin County, eastern Texas (*E. J. Palmer*, No. 13098 in Herb. Mo. Bot. Gard.). In Texas it seems to be the only species. Its usual habitat is hammocks or hardwood lands although it enters pine woods on good sites. While related to *P. depressum*, having foliage decidedly pubescent on both faces, it is less pubescent and less glandular than that species and of larger size, from 5 to 9 dm. high. Type: *Langlois*, Covington, La., Apl. 16, 1894. (Univ. of Notre Dame, Ind.)

12. **Polycodium arcuatum** sp. nov.

From 1.5 to 3 m. high; leaves yellow-green, pubescent on both faces, ciliate, finely reticulated, oblong-ovate to lanceolate, 5 to 7.5 cm. long by 2 to 3 cm. wide, acute at apex; twigs and arcuate rachis pubescent; bracts 2 to 3 cm. long by .7 to 1.5 cm. wide, ovate, mostly acute at apex, rounded or subcordate at base, the lower glandular ciliate, the slender pedicels often equalling or exceeding the bracts; calyx mostly hirsute lobes oblong, accrescent; corolla deeply notched with rounded lobes, about 6 mm. long; fruit at length nearly black, shining, puberulous, ripening in July.

Growing with hardwoods on the edges of swamps or in pine lands of good quality, Florida parishes of Louisiana northward to Simpson Co., Miss. (*W. W. A.*) Type: McNeill, Hancock Co., Miss., May 8, 1930, *W. W. A.* Bayou LaCombe, Pointe à la Hache, Plaquemines Parish, La., June, 1880, *Langlois* (Nat'l. Herb.). This is the only species belonging to the *sericea* group which prevailingly seems to have foliaceous bracts.

13. **Polycodium kunthianum** C. B. Robinson in Tor. Bull. **39**: 559. 1912.

Vaccinium kunthianum Klotzsch in Linnaea **24**: 56. 1851.

V. stamineum β H. B. K., Nov. Gen. & Sp. **3**: 267. 1819.

The excellent original description and accompanying plate leave doubt chiefly as to the color and other characteristics of the mature fruit of

this species. The plate shows a plant with oblong calyx lobes and pubescent calyx, with reduced bracts and bracteolate pedicels. This description was supplemented by notes furnished me by Mr. C. A. Weatherby upon specimens of this species in the Gray Herbarium. Prof. Diels, Director of the Berlin Botanical Gardens and Museum, kindly sent me a photograph of the type sheet which is in the herbarium of the Botanical Gardens.

14. **Polycodium melanocarpum** Small, Fl. S. E. U. S. 894. 1903.
Vaccinium melanocarpum Kearney in Tor.Bull. **24**: 570. 1897.
V. stamineum melanocarpum Mohr in Tor. Bull. **24**: 25. 1897.
Not *P. melanocarpum* Small as described by him (l. c.).

In the Plant Life of Alabama the type locality is given by Mohr as "mountain region of Alabama, more especially St. Clair County near Asheville," but the type specimen in the Mohr herbarium, examination of which was permitted through the kindness of Dr. B. P. Kaufman, is from Springville, Ala., in immature fruit, June, 1880; while on the same sheet is "fully mature fruit purple-black with bloom from Ashland (Clay County), Ala., July 20, 1892." Both specimens are entirely glabrous. A similarly glabrous specimen in the National Herbarium on which there is a note to the effect that it was selected by Mohr from which to make the plate for the illustration of this species in the Plant Life of Alabama is from Mentone, Lookout Mtn., DeKalb County, Ala. Although both descriptions, as a variety and when considered by Mohr as a species, (Pl. L. Ala. 658. 1901) give the foliage as "smoothish or slightly pubescent" all of the numerous specimens collected by him at Springville (type), St. Clair County; Asheville, St. Clair Co.; Mentone and Albertville, Marshall Co. (material from these last three stations in the National Herbarium) are strictly glabrous, and seemingly this species should be restricted to the glabrous plant which is common in this mountain region and which his plate clearly represents. Doubtless these references to pubescence were due to the inclusion at first of *P. sericeum*, a pubescent plant, as a variety. *Polycodium melanocarpum* is seemingly a species of limited range, restricted to northeastern Alabama (*W. W. A.*, Sand Mtn., Jackson County, north of Scottsboro, June and August, 1930, where very common) and to the adjacent portion of Georgia (*W. W. A.*, north of Columbus, Muscogee Co.) and collected by Mohr at many intermediate points. It probably extends along the Cumberland Plateau into Franklin County, Tenn. Small's *P. melanocarpum* as described seemingly does not include Mohr's plant.

15. **Polycodium bellum** sp. nov.

Low, 3 to 5.5. dm. high, single or several stems in a cluster. Leaves bright green on both faces, lucid and glabrous above, pubescent on veins beneath, lanceolate, broadest near the middle, 1.3 to 1.8 cm. wide, 4.5 to 6.2 cm. long, about 3 times as long as wide, taper-pointed, subcordate or rounded at the narrowed base, finely but inconspicuously reticulated, ciliate. Inflorescence glabrous or sparingly pubescent; flowers rather small, about 6 mm. long to the tips of the long rounded corolla lobes; calyx tube glabrous, the short or narrowly triangular lobes sometimes ciliate at tip or pubescent, erect on fruit or with tips recurved; fruit small, 7 to 10 mm. thick, black or red black, glabrous and shining, pedicels mostly shorter than the thickness of the fruit and about one-half the length or rarely longer than the oblong or linear ciliate bracts.

The narrow, small, bright green foliage is distinctive while growing. Old herbarium specimens resemble *P. melanocarpum*, which, however, has larger leaves, quite glabrous. In *Pinus echinata* and oak woods, western Florida, River Junction (*W. W. A.*, Aug., 1926) to the hills along the Mississippi river in Franklin, Jefferson, and Adams counties, Miss., where very common. Type: *W. W. A.*, Adams Co., Miss., Aug., 1929.

16. **Polycodium candicans** Small at least in part, Fl. S. E. U. S. 894. 1903.

Vaccinium melanocarpum candicans Mohr in Plant Life of Ala. 658. 1901.

This is a species of limited distribution, represented by only a few specimens in herbaria. No. 54396 Biltmore Herbarium agrees with Mohr's description. It is characterized as follows: Leaves of an oblong type, minutely pubescent above, white glaucous and velvety pubescent beneath, ciliate; bracts much reduced, ovate or elliptical, pubescent like the leaves, ciliate, cilia often intermixed with gland-tipped hairs; fruit purple-black, glossy beneath a heavy bloom; calyx lobes usually oblong, sometimes broadly triangular, not accrescent nor prominent on the sometimes obovate fruit; the base of the shoots and inflorescence often glandular pubescent and rarely the fruit; flowers unknown.

Mohr says (op. cit.): "Leaves smaller than in the type," (i.e. *melanocarpum*) "the lower surface covered with a close fine, almost milk-white tomentum." Type locality and type collection: "Auburn, Lee Co.,

Ala., *Baker* and *Earle*, August, 1897." No. 54396 *Bilt. Herb.*, July 31, 1902, Coosa Co., Ala. (N. H.). West to Perry Co., Ala., *W. W. A.*, Nov., 1929. Reported by Harbison as far east as Highlands, Macon Co., N. C. These specimens show a plant somewhat similar to *P. sericeum* in its glandular pubescence, but having a different leaf form and fruit. There is no specimen to represent this species in the Mohr herbarium, at the University of Ala.

17. **Polycodium interius** Ashe in Chas. Mus. Quar. 1: 32. 1925.

Divaricate, 3 to 6 dm. high with underground stems; leaves 6 to 8 cm. long, lanceolate or broader, yellowish green, with prominent yellow midrib and reticulated veins, essentially glabrous; inflorescence as a rule glabrous except for cilia on the broadly ovate or elliptic much reduced bracts, the cilia sometimes gland-tipped; fruit 9 to 12 mm. thick, dark red or purplish, dull, ripening late in July.

In rocky oak or *Pinus echinata* and oak woods from middle Louisiana (*W. W. A.*), to southern Missouri (*W. W. A.*, Monteer, June 26, 1924) and eastern Oklahoma (*W. W. A.*, LeFlore Co., May 12, 1930). East of the Mississippi river in the mountain region of northwestern Alabama represented only by the variety *subglandulosum*.

Type locality near Lurton, Newton Co., Ark., *W. W. A.*, May, 1924 and September 1, 1923.

Polycodium interius has a general resemblance to *P. melanocarpum* which, however, has fruit glossy black beneath a bloom, and leaves bright green above and glaucescent beneath. The fruit of *interius* is dark red and the foliage yellow-green on both faces and often strongly reticulated.

17a. **P. interius commune** var. nov.

Leaves more or less pubescent beneath especially in the veins. The more common and widely distributed form, extending to southeastern Kansas, Cherokee Co., *E. J. Palmer*, No. 20874, Apl. 22, 1922. Type: *W. W. A.*, Hot Springs Mtn., Garland Co., Ark., Apl. 24, 1928 (flowers); June 26, 1929 (fruit).

17b. **P. interius subglandulosum** var. nov.

Inflorescence glandular pubescent, otherwise often glabrous; fruit occasionally glandular. Hot Springs Mtn., Garland Co., Ark.; Lawrence Co., Ala., (type., *W. W. A.* Aug. 1, 1928). Hybrids with *P. sericeum* occur.

18. **Polycodium neglectum** Small, Fl. S. E. U. S. 893. 1903.

Pennsylvania south to middle Georgia, west through eastern Tennessee and Kentucky to southern Indiana. This species is based upon Wilson's No. 159, Georgia Plants, Crawford County, south central Georgia (N. Y. Bot. Garden). Dr. Small kindly allowed me to examine the type sheet. Collections have also been made in the type locality with the object of determining the color of the mature fruit which is described as being green or yellow. Plants occur there which have such fruit ripening in July and with the leaves pale beneath as described. The usual height of these plants is from 4 to 8 dm. In the mountains of southwestern North Carolina there occurs what seems to be a well marked variety and which can appropriately be called the following.

18a. **P. neglectum harbisonii** var. nov.

This differs from the type in its larger size, occasionally becoming 12 to 15 dm. tall, in its consistently densely glaucous as well as glabrous foliage and twigs and in its later maturing fruit, ripening late in September and October, which is pink or purplish, never yellow or white.

Type in both flower and fruit, Satula Mountain, Macon County, N. C. *T. G. Harbison* and *W. W. A.* Mr. Harbison has done much to make known the woody plants of the Highlands Plateau.

Polycodium neglectum hybridizes freely with *P. stamineum.*

19. **Polycodium parvum** sp. nov.

A dwarf shrub 1 to 3 dm. high with underground stems. Twigs very slender, glabrous or puberulous; Leaves oblong-ovate to oblanceolate, small, 3 to 5 cm. long by .9 to 2 cm. wide or on vigorous shoots up to 7 cm. long by 2.5 cm. wide, narrowed to the rounded base, thin but firm, often ciliate, glabrous on both faces or pubescent beneath on the veins, pale and somewhat glaucous beneath, finely reticulated. Calyx lobes triangular, acute, somewhat ciliate, hypanthium and fruit glabrous; fruit, ripening in early August, dark red to nearly black, sparingly glaucous 9 to 14 mm. thick. Inflorescence glabrous but the base of the shoot of the season and the base of the inflorescence sometimes with a few stalked glands.

Southwestern Georgia and adjacent Alabama, in *Pinus echinata* and broadleaf woods. Type: Cuthbert, Ga., *W. W. A.*, September 5, 1928 and July, 1930.

20. **Polycodium stamineum** Greene, Pitt. **3**: 324. 1898.
Vaccinium stamineum L, Sp. Pl. Ed. 1, **1**: 350. 1753.
V. album Pursh, **1**: 285. 1814.
V. elevatum B. and S. in DC. Prod. **7**: 567. 1842.

Leaves pale beneath, pubescent on veins; fruit green or yellow; 4 to 12 dm. high. Massachusetts through middle New York to Ontario, south to northern Georgia, west through east Tennessee and Kentucky to southern Indiana. Type: Linnean Herbarium.

Thanks are due to Mr. G. Taylor of the British Museum for making a number of comparisons with specimens of *Polycodium stamineum* in that institution.

20a. **P. stamineum affine** var. nov.
P. candicans Small (in part), F. S. E. U. S., Ed. 1, 894. 1903.
Not *V. sericeum candicans* Mohr, l. c.

Leaves white glaucous and soft pubescent beneath; fruit green or yellow. With the type form, especially southward.

20b. **P. stamineum austro-montanum** var. nov.

Leaves oblong or ovate-oblong, ample 6–12 cm. long; calyx usually pubescent, lobes sometimes oblong; fruit claret-colored, 10–14 mm. thick; often a single-stemmed shrub becoming 2 m. high. Northeastern Georgia. Type: *W. W. A.*, Porter Spring, Lumpkin Co., Ga., May and Aug., 1925.

20c. **P. stamineum Virginianum** var. nov.

Fruit red or russet, subglobose, obovate, or sometimes even ovate; leaves barely pale and sparingly pubescent beneath; low, 4 to 6 dm. high. Common in the mountains of northern Virginia and adjacent West Virginia. Type: *W. W. A.*, Massanutten Mountain, Shenandoah County, Va., September, 1912.

A specimen of this species from Sand Lake, N. Y., *C. H. Peck*, submitted by Dr. H. D. House has bracteolate pedicels, but otherwise is typical.

21. **Polycodium arenicola** sp. nov.

A spreading shrub 1 to 2.5 dm. high forming large groups by means of extensive underground stems. Leaves oblong or oblong-ovate, 1.5 to 1.8 cm. wide, 3.5 to 4.5 (−5.5) cm. long, above dull, and usually glabrous except on puberulous midrib, pale and more or less pubescent

beneath and finely reticulated, the margins ciliate, sometimes slightly revolute; twigs slender, pubescent. Bracts same shape as leaves, but smaller, sometimes much reduced; flowers usually purplish, 5–6 mm. long to the tip of the short, broad, rounded lobes; anthers pubescent, appendages long and upcurved; calyx glabrous; fruit 9 to 14 mm. thick, dark red, glabrous, ripening the last of June.

With longleaf pine of small size on driest sands, particularly the St. Lucie sand. Cumberland and Onslow counties, North Carolina to Hampton County, South Carolina. Type: *W. W. A.*, Bladen County, N. C., May 1, 1929 (flowers); July, 1929 (fruit).

UNKNOWN

Polycodium oblongum Greene, Pitt. **3**: 325. 1898.

Vaccinium oblongum Greene, Pitt. **3**: 250. 1897.

The type locality is near Dover, Tenn., on a hill near the Cumberland River. The type specimen, in flower only, is at Notre Dame University. It has not been possible to secure material from the type locality to determine its status. It is described as being a shrub 3 to 5 feet high, and having pedicels exceeding the length of the immature leaves. Deem[9] refers to a form about 1 m. high and having purplish fruit, as growing in southern Indiana. This may represent *P. oblongum*.

[9] Shrubs of Ind. 265. 1924.

A NEW SPECIES OF TRICHODINA FROM A SALAMANDER

By Yasushi Ibara

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Plate 12

A ciliate of the genus Trichodina was discovered in the urinary bladder of specimens of a salamander, *Hynobius tokyoensis* Tago, by Dr. A. S. Pearse who furnished living material to the writer for study. The salamanders were collected from ditches and puddles bordering rice fields near the village of Tanichi, about thirty miles north of Tokyo, during March and April, 1929 and 1930. Thanks are due to Mr. K. Tago who showed Dr. Pearse and the writer where to collect the salamanders. In the infested individuals the ciliates usually occurred in great numbers attached to the inner wall of the bladder and none was found in any other internal organ. Grassi (1882), Rosseter (1886), and Embleton (1900) have reported *Trichodina* sp. from the urinary organs of *Triton cristatus* Laurenti, the common European newt. The present species differs from that described by those observers in the number and arrangement of the radiating chitinous rods around the aboral disc (36:30), the length and arrangement of the cilia, and the shape and size of the body. It is named for Professor Keiji Okajima, who has made considerable contributions to the study of Japanese salamanders and has greatly helped the writer. The following description has been written after studying living trichodinas; and specimens treated with borax-carmine, iron-haematoxylin, and Giemsa's stains after fixation in Schaudinn's fluid.

Trichodina okajimae n. sp.

(Infusoria; Ciliata; Peritrichida; Vorticellidae; Urocelarinae)

The form of this ciliate varies between cup-shaped and pyriform (Fig. 8) and may at times be flattened at the distal end. On permanent slides the length is 0.045 to 0.07 mm. (ave., 0.057 mm.) and the width 0.04 to 0.06 mm.

The proximal disc is concave and may be flattened against and ad-

here to a surface. It bears a marginal ring of cilia which measure 0.02 to 0.04 mm. in length. Each cilium is bifid at its tip (Fig. 3b), and tapers distally. It contains an elongated, ellipsoidal basal body. Outside the base of each cilium is a stout, spatulate process (Fig. 3). The disc is supported by an elaborate group of skeletal structures, which are arranged radially, and has a total diameter of 0.02 to 0.04 mm. Around the wall of the proximal sinus 34, 36, or 38 slightly tapering, striated rods extend more or less horizontally. Each of these is surmounted distally by a short discoidal piece which extends somewhat horizontally and at the tip of each of these is a slender, conical process the tip of which extends toward the center of the cell (Figs. 1, 3a, 4, 5, 6, 7).

The oral disc may vary greatly when seen from the side because the area within the ring of cilia may be flattened or protruded as a hemisphere. The slender oral cilia measure 0.004 mm. in length. They appear to vary slightly in arrangement in different individuals (Figs. 11, 12) but usually form a single ring about 0.04 mm. in diameter. At one side of the ring the cytostome leads into a gullet which extends into the interior as a slender tube with one or two coils.

The contractile vacuole lies just behind the oral disc at one side of the body. When distended it measures about 0.01 mm. in diameter.

The macronucleus varies in form (Figs. 13, 14, 15) but usually occurs as an irregular band about 0.0035 mm. in width which forms a broken ring about 0.025 mm. in diameter. At times it is in two parts and occasionally it does not form a ring. The micronucleus (Fig. 13) is ellipsoidal and measures about 0.0036 by 0.0025 mm. It is enclosed in a shallow cavity in the macronucleus.

The locomotion of this ciliate is peculiar. When the animal is swimming freely the posterior disc is often hollowed out deeply, so that the whole body resembles a minute tea cup without a handle. At times the disc closes like a "Molochan maw" and the body then becomes pyriform. The movements are on the whole rather jerky and erratic. When attached the whole body may rotate on its longitudinal axis, like that of Didinium. This rotation appears to be brought about largely by the cilia on the oral disc, while the cilia around the proximal disc are nearly or quite immobile. When taken from the bladder of a salamander and placed on a slide in tap water these ciliates remain alive for many hours, swimming about or remaining attached to the glass.

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EXPLANATION OF PLATE 12

TRICHODINA OKAJIMAE, N. SP.

FIG. 1. Camera ludica drawing, proximal disc showing the central protoplasmic area, the radiating rods of the supporting skeleton, the protoplasmic ridge from which the cilia arise, and the cilia.

FIG. 2. Free hand drawing of an individual attached to the wall of the bladder. The large clear area near the center is the contractile vacuole.

FIG. 3*a*. Optical section (camera lucida) to show arrangement of rods of skeleton in proximal disc and relation of cilia to them.

b. Single cilium and protoplasmic protuberance at its base.

FIG. 4. Showing relation of cytostome, gullet, and proximal disc in a stained specimen; as seen in a postero-lateral view.

FIG. 5. Longitudinal optical section (free hand).

FIG. 6. Proximal skeleton in a preparation stained with Giemsa.

FIG. 7. Proximal skeleton with cilia, stained with iron-haematoxylin. A portion of the ciliary ring has been torn away and thus the protoplasmic protuberances are shown at the bases of the cilia.

PLATE 12

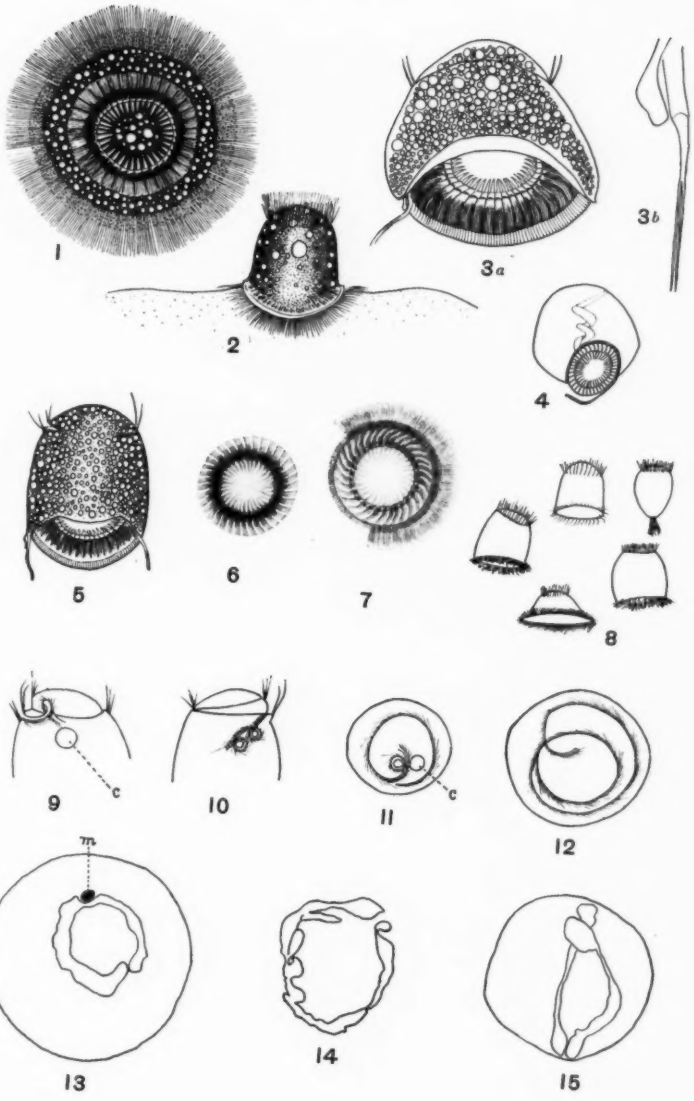

FIG. 8. Shapes assumed while swimming (free hand).

FIGS. 9, 10. Lateral view of oral disc with cytostome and contractile vacuole (*c*).

FIGS. 11, 12. Arrangement of cilia around oral disc (free hand).

FIGS. 13, 14, 15. Nuclei in preparations stained with carmine (camera lucida). *M*, micronucleus.

SYMPLOCOS TINCTORIA ASHEI

A New Dyebush from the Southern Mountains

By T. G. Harbison

Symplocos with more than two hundred species inhabits the warmer parts of Asia, America and Australia. It is represented in the United States by *Symplocos tinctoria* L'Her.,[1] ranging from the peninsula of Delaware to eastern Texas following the coast. It extends inland to northern Alabama, north-eastern Mississippi and southern Arkansas. It is also found in the southern Appalachian mountains, ascending to an altitude of 4,500 feet in North Carolina.

Symplocos tinctoria has long been considered the only form that occurs in North America, not even a variety having been attributed to it. A reference to the descriptions of this species by the several authors who have described it leads one to the conclusion that it is either a very variable species or that two forms are included under one description. For many years this small tree had been observed by the writer in the field, from the high mountains to the coast, and its variations noted, but these variations were attributed to climatic and ecological causes. It was not until W. W. Ashe several years ago called my attention to the fact that Symplocos inhabits two separate areas and that two forms of this are constant in their characters in their respective areas, that I took up the study of Symplocos in earnest.

One of these forms extends from Delaware to Texas, essentially coastal, and following on the Atlantic seaboard more or less closely the distribution of cypress reaches an altitude of 500 feet in only a few places. In this area the habitat of Symplocos is largely restricted to the margins of swamps and to the sandy soil of the coastal plain formations with their accompanying pines, gums and bays. The other area restricted to a limited region in the southern Appalachian Mountains, lies in general between 1,800 and 4,500 feet altitude. Symplocos in this area is associated with *Pinus rigida*, *Quercus coccinea*, chestnut oak and chestnut of small size. The mountain area is separated from the coastal plain

[1] *Symplocos tinctoria* L'Heritier, Tr. Linn. Soc. **1**: 176. 1791. *Hopea tinctoria* Linn., Mant. 105. 1767.

area by a zone from one hundred to two hundred miles in width in which Symplocos is not known to occur. This region is occupied by *Pinus echinata* with its associated oaks and hickories.

In the late autumn and early winter of 1929, while doing field work under the direction of E. N. Lowe, State Geologist of Mississippi, I had an excellent opportunity to trace the distribution and study the character of Symplocos in that state. I visited all parts of the state and learned that only one form, the coastal plain form which is the type of the species,[2] occurs in Mississippi. In the fertile river bottoms usually inundated several weeks of the year Symplocos reaches its largest size. Trees nearly a foot in diameter and 40 feet tall were observed. On January 1st these trees had the appearance of being evergreen, but like several of the so-called evergreen oaks they are not strictly speaking evergreen. Herbarium specimens showing both leaf and flowers on the same branch have leaves of the previous year, and many specimens have both old and new leaves; but the leaves begin to drop in midwinter and by spring most of the leaves have fallen, so strictly speaking *Symplocos tinctoria* is not evergreen, even in Florida. Specimens in the National Herbarium from Virginia exhibit this persistent character as well as those from the southern limit of the species. No. 355894 collected by Thos. H. Kearney, Jr., in Princess Anne County, Va., May 14, 1898, has new leaves fully half grown and still holds many of the leaves of the previous year. The mountain form drops its leaves soon after the first killing frost and no leaves persist till the following spring. This is true of this form in Georgia, its southern limit.

Mr. Ashe has loaned me his complete collection of Symplocos material for study. Both forms are well represented from North Carolina to Texas and Arkansas. The National Herbarium has loaned me material representing the Coastal Plain species as it occurs in Delaware and Virginia. I have in my own collection abundant material from Virginia to Florida and Arkansas. A careful study of this material after many years' observation in the field leads me to the conclusion that the mountain form is a valid variety. A description of the mountain form which seems to be unnamed and the characters which separate it from the coastal form follow:

Symplocos tinctoria ashei var. nov.

A shrub or small tree becoming 6 m. in height. Leaves deciduous,

[2] Symplocos was discovered by Mark Catesby in the coastal region of South Carolina and the first description is found in his natural History of Carolina published in 1731. It is from Catesby's book that Linneaus drew his description.

oblong, broadest at the middle, about twice as long as broad, acute at base, acute or sometimes acuminate at apex, largest about 12 cm. long by 7.5 cm. wide, prevailingly 6 cm. to 11 cm. long by 3 to 6 cm. wide, sometimes serrate, permanently soft reddish or rusty pubescent beneath, pubescent above with short appressed hairs; shoot of season and petiole villose or pubescent with reddish-brown, rarely grayish, spreading hairs; divisions of corolla rounded or acute; fruit fully 1 cm. long, pubescent; bracts densely pubescent and ciliate.

The coastal form which is typical *S. tinctoria* is characterized as partially evergreen; leaves oblanceolate, tapering at base, acute at apex, broadest above the middle, maximum size 15 cm. long by 5.5 cm. wide, more than twice as long as wide, the usual size 7 cm. to 12 cm. long by 2.5 cm. to 5 cm. wide, entire or finely crenulate, glabrate or sparingly pubescent below with pale hairs, soon glabrous above; shoot of the season glabrous or at first pubescent with pale chiefly appressed hairs, eventually becoming glabrous: divisions of the corolla rounded; fruit 8 mm. long, glabrous or glabrate; bracts sparingly pubescent, ciliate.

Symplocos tinctoria ashei occurs on dry ridges chiefly on acid red clay soils from Watauga and Madison Counties, N. C. southward to Pickens County, S. C., Lumpkin and Fannin Counties, Ga., and to the extreme eastern end of Polk County, Tenn., being the most abundant along and near the Blue Ridge from Caldwell County, N. C. (southern slope of Grandfather Mountain at an altitude of 4,500 feet) to Towns and Lumpkin Counties, Ga. It is common in the vicinity of Highlands, Macon Co., N. C., where the type material was collected on Scaly Mountain (Ashe herbarium).

HIGHLANDS, N. C.

OCCURRENCE AND HABITAT OF CORDYCEPS AGARICIFORMIA (BOLT.) SEAVER IN FLORIDA

By GEORGE F. WEBER

PLATES 13, 14

On January 6, 1923, the writer collected specimens of *Cordyceps agariciformia* (Bolt.) Seaver in the vicinity of Gainesville, Florida. No particular significance was attached to this collection at the time but during the early part of January, 1924, another collection of the fungus was made in the immediate locality of the first. Since that time collections have been made in January of each year, including 1931, in the identical location and the name "Cordyceps Hill" has been applied to the area. Recent developments in that immediate vicinity will probably involve the fruitful location and destroy it for *Cordyceps* production. In addition to establishing the identity of the fungus and record of collections the purpose of this paper is to describe the location so that other collectors may be benefited.

Specimens of the early collections were sent to several mycologists for identification and were classified by all of them as *Cordyceps capitata* Holmsk. The Florida specimens were parasitic on *Elaphomyces cervinus* (L. ex S. F. Gray) Schl. as recorded by Seymour (13). *Elaphomyces granulatus* (Alb. & Schw.) Fr., the host reported by Berkeley (4) and Cook (5), is listed as a synonym. Ellis and Everhart (7) (8) report the hosts as a *Scleroderma* collected in Carolina by Ravenel and a Tuberaceous fungus collected in Florida by Calkins. Seaver (12) retained *Scleroderma* in listing the hosts and added *Elaphomyces* sp. Ellis and Everhart (8) described *Cordyceps ophioglossoides* Ehr. as parasitic on *Elaphomyces granulatus* the host of *Cordyceps agariciformia*. Engler and Prantl (9) showed figures of the host *Elaphomyces cervinus* that compare very well with the host of the Florida specimens. Their illustrations of *Cordyceps ophioglossoides* Erh. show long fusiform stromata and root-like growths radiating from the base of the stipe that distinctly set it off as entirely different and not easily confused with the Florida specimens. Persoon (10) also showed illustrations which are undoubtedly these two species and they certainly are dis-

tinct. A comparison of the Florida specimens with Dodge's (6) illustrations and descriptions indicates that it is *Elaphomyces cervinus*. Consequently, the Florida specimens will hereby be classified according to Seaver (12) and the host according to Seymour (13) namely, *Cordyceps agariciformia* (Bolt.) Seaver, parasitizing *Elaphomyces cervinus* (L. ex S. F. Gray) Schl.

Distribution. Stover and Johnson (14) reported this parasite from Ohio and according to reports of Seaver (12) the range of this fungus is listed as Maine to Ontario and Florida. Saccardo (11) lists European countries as Britain, Finland, Germany, France, Belgium and Italy. Collections have been recorded from Wales (2) and Scotland (1). In Florida the only records available show that it was collected near Gainesville by the writer and at Rock Springs by E. West (specimens in the University Herbarium). The two Florida localities, although more than a hundred miles apart, are almost identical in relation to vegetation, soil, exposure, etc. The soil is almost entirely a yellow sand of the Norfolk series and of considerable depth. The soil would be considered dry, although always in January when collections were made there has been moisture present an inch below the soil surface. The surface is sloping enough for good drainage. The vegetation is exceedingly sparse, consisting of wire grass and a few scattering native plants of Compositae. Scattered more or less irregularly over the whole field are groups of scrub and turkey oak, and occasional long leaf pine of considerable size, clusters of wild plum and hawthorn and thick clumps of saw palmetto. Mats of reindeer moss, *Cladonia rangiferina* L. are scattered promiscuously over the surface of the ground and the tree trunks and twigs are decorated with *Usnea barbata* (L). Fr. and *Chiodecton rubro-cinctum* Nyl. The most characteristic growth observed since collections were first made and which is always present in abundance is *Leotia chlorocephala* Schw. Collectors of *Cordyceps* in England (3) have noted the promiscuous presence of this fungus in the same vicinity with it. In both Florida localities where collections of *Cordyceps* have been made the *Leotia* sp. has been fruiting conspicuously.

The figures designated by the arrows in the landscape (pl. 13) show two clumps of *Cordyceps* in relation to their environment. The *Elaphomyces* collected in the Gainesville area were buried from two to four inches in the sand. Their outer wall is quite granular and compares favorably with Fig. 221–c of Engler and Prantl (9). They are usually irregularly spherical, as shown in Fig. 4. The ascospores of the parasitized individual have been found to be more opaque and average 1.5–

PLATE 13

CHARACTERISTIC VEGETATION SURROUNDING FRUITING CORDYCEPS AGARICIFORMIA (BOLT.) SEAVER (INDICATED BY ARROWS)

2μ larger than the ascospores from unparasitized specimens. The stipe of the parasite has been usually quite firmly attached to the host, often slightly bulbous and destitute of any kind of root-like rhizomorphic growths. Approximately half of the entire length of the parasite is buried. A total length of 6 inches will usually show 3 inches above ground. The period of time between the emergence of the fungus until its disintegration in several instances was approximately 3 weeks. Figure 5 shows a group of stromata in nature and Fig. 2 shows a single plant slightly enlarged to show the top of the perithecia that are imbedded in the stromata.

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EXPLANATION OF PLATE 14

FIG. 1. Several stromata of the parasite arising from a single large specimen of *Elaphomyces cervinus* (L. ex S. F. Gray) Schl.

FIG. 2. Mature perithecia discharging ascospores on surface of stromata. (Spore clusters are white.)

FIG. 3. A typical specimen of parasite and host. In nature half the total length is below the soil surface. About natural size.

FIG. 4. An unparasitized specimen of *E. cervinus*.

FIG. 5. Several fruiting structures about natural size in nature. Photographed Jan. 4, 1927.

PLATE 14

OBSERVATIONS ON SOME SPECIES OF WATER MOLDS CONNECTING ACHLYA AND DICTYUCHUS

By JOHN N. COUCH

PLATE 15

As work on the water and soil fungi proceeds, new forms are being found which tend to break down the clear distinctions between certain old genera. Three such species have recently been found which are intermediate between *Dictyuchus* and *Achlya*. The first was described by Coker and Braxton (This Journal **42**: 139, pl. 15. 1926) as *Dictyuchus* sp., a homothallic strain; the second was described by Coker and Alexander (This Journal **42**: 218, pl. 36. 1927); and the third is being described here. All three of these forms show remarkable relationships both to *Achlya* and *Dictyuchus*. The writer gratefully acknowledges many helpful suggestions from Dr. W. C. Coker, concerning the taxonomy of this genus.

In *Achlya* the spores are normally discharged from the sporangium through an apical pore and there encyst in a more or less regular hollow ball. In *Dictyuchus* the spores encyst within the sporangium, and due to the pressure of the spores against each other and against the sporangial wall during encystment, the surfaces of the spores are flattened and in contact with each other usually without any intersporal spaces. Therefore, when the individual spores emerge, each from its own cyst, a more or less perfect net is left by the empty cysts. Frequently in *Dictyuchus* sporangia occur in which there is sufficient space between the spores for them to round up, more or less, as they encyst thus leaving intercellular spaces between the spores. Sometimes in extra large sporangia a considerable space may be left in the center. In *Achlya*, as has been noted by many observers, the spores may round up and encyst within the sporangium, emerging later from their individual cysts, thus leaving a false net formed by the more or less round, empty cysts. Sometimes, however, apparently true dictyosporangia may be formed in *Achlya* (Coker, The Saprolegniaceae, *A. apiculata*, pl. 42) as well as in other species.

In depauperate sporangia of *Dictyuchus* a false net may be left due to the spores rounding up as they encyst, but never has a strain of *Dictyuchus*, the spores of which regularly form a true net, been induced

to form *Achlya* sporangia. In the three species now under consideration the primary sporangia may be of the *Achlya* type; the later sporangia, and usually in two of the species all of the sporangia, are of the false-net type. The false-net type of sporangia found here is quite distinct from the false-net type which occurs sometimes in *Achlya*, for in the latter genus the sporangial wall persists while here the wall disappears during the encysting of the spores. Thus there is nothing to hold the spores together here except the sticky surfaces of their walls. The ease with which these spores may be separated from each other may be demonstrated by the following simple experiment. If a considerable group of sporangia of the false-net type containing encysted spores are crushed under a coverglass by gentle pressure, the spores are separated from the mass singly or in groups of twos or threes or more. If, however a group of the true-net type of sporangia containing encysted spores are treated in the same way, the entire protoplasmic contents of the sporangia may be pressed out until nothing but a net of empty cysts is left, but never can the spores be made to separate from the mass.

Dictyuchus monosporus Leitgeb and its various strains normally produce sporangia of the true-net type, while *D. pseudodictyon* Coker and Braxton, *D. achlyoides* Coker and Alexander, and the species of *Dictyuchus* described herein produce sporangia of the false-net type. The latter three species also produce sporangia of the *Achlya* type under certain conditions, while the former never produce *Achlya* sporangia. Basing generic distinctions on sporangial characters alone, it would seem justifiable to make a new genus to include the species with the false-net type of sporangia and with the ability to produce primary sporangia of the *Achlya* type. But considering the rather close uniformity in the size and structure of the oogonia and eggs, and the single-egged characteristic of the oogonia throughout all these species, it seems best to extend the limits of the genus *Dictyuchus* to include these species rather than to establish a new genus.

The following revision of the genus will include the three species with sporangia of the *Achlya* type and later sporangia of the false-net type.

Dictyuchus

Mycelium usually quite vigorous, reaching a diameter of 2–3 cm. on hemp seed; threads branched, up to 100μ thick at the base, straight at first except where branched, becoming quite zigzag as the culture ages by the continued formation of apical sporangia from the base of which

the thread continues its growth. Sporangia found in great abundance, at first around the outer margin of the culture, later scattered over the entire culture, first sporangia long cylindrical, often thicker in the distal half than in the proximal; sporangia in the *D. monosporus* group and in *D. pseudodictyon* Coker and Braxton often breaking away from the hyphae and floating on the surface of the water. Often the greater part of hyphae may become sporangia and sometimes oogonial and antheridial branches may become sporangia. Sporangial wall persistent in the *D. monosporus* group; quickly disappearing in the false-net group. Spores encysting within the sporangia, emerging later in the laterally biciliate form leaving their empty cysts in the form of a net. Primary sporangia in some species of the *Achlya* type. Plants heterothallic, homothallic, parthenogenetic, or apparently sexually sterile. Oogonia when present with a single eccentric egg (with the exception of the very doubtful species *D. polysporus*).

KEY TO THE SPECIES OF DICTYUCHUS

A. Sporangia of one kind, the spores emerging to leave a true net.
D. monosporus Leitgeb

B. First sporangia of the *Achlya* type, later sporangia of the false-net type.
Oogonia papillate.....*D. achlyoides* Coker and Alexander

C. All sporangia normally of the false-net type, oogonia smooth.
Antheridia absent.....*D. missouriensis* n. sp.
Antheridia usually present.....*D. pseudodictyon* Coker & Braxton

Dictyuchus missouriensis, n. sp.

Mycelium fairly vigorous, reaching a diameter of 2 cm. on hemp seed. Largest threads up to 75μ thick near base, most about 50–60μ thick. Threads more or less wavy throughout and zigzag in the distal half by the formation of sporangia and renewed growth from beneath. Sporangia cylindrical, thickest in the middle part, 10–40 x 84–400μ, most 25–35 x 250–300μ; sporangial wall thin, disappearing soon after the spores are formed. Spores usually rounding up more or less and encysting within the sporangium and thus forming only an imperfect net; emerging from their cysts and swimming in the laterally biciliate form. By special treatment the early formed sporangia may be induced to discharge as in *Achlya*. Spores about 10μ thick when encysted. Gemmae very rare, formed only in old unhealthy cultures, spherical to elliptic. Oogonia formed in abundance after about two days on hemp seed and bits of boiled corn grains, borne on rather thin, lateral branches which are usually two to three times as long as the diameter of the oogonium; stalk usually crooked at the base of the oogonium and oogonium often joined to the stalk by a beak-like process from its base; spherical except for the basal elongation; usually about 33μ thick, but varying from 29–44, rarely 60μ thick. Eggs single, eccentric, 23–38μ, usually 26μ thick. Antheridia absent.

Collected once, October 24, 1926, on a soil collection west of Jefferson Barracks, St. Louis, Mo.

Distinguished from *D. pseudodictyon*, to which it is closely related, by the shape and habit of the sporangia. In *D. missouriensis* the sporangia are comparatively short and thick and are seldom if ever branched. In *D. pseudodictyon* the sporangia are long and thin and are often very complicately branched. Moreover, in the former the sporangia are thickest in the middle, while in the latter species they are distinctly thicker in the distal portion; also distinguished from *D. pseudodictyon* by the absence of antheridia; by the peculiar, bent beak at the base of most of the oogonia; and also by the formation of gemmae in some cultures. The size of the oogonia and eggs is about the same in the two plants.

Dictyuchus pseudodictyon Coker and Braxton. This Journal **42**: 144, pl. 15. 1926.

This species was first described by Coker and Braxton, but because of its doubtful position, they did not give it a name. In the original description it was stated that the antheridial tube was not observed. With an oil immersion lens, however, antheridial tubes were visible. A number of oogonia with antheridia were examined and it was very interesting to find that even where there were several antheridia on the same oogonium only one tube was seen to enter. The above name, given by Dr. Coker, is here published for the first time.

This species normally produced only false-net sporangia, but the *Achlya* type of sporangia has been induced by the following experiments: Cultures were started on hemp seed in double distilled water and after two days were transferred to double distilled water which had been treated with blood or animal charcoal. Twenty-four hours after the transfer, sporangia of the *Achlya* type were formed in abundance. Only the first crop of sporangia were of the *Achlya* type, the later ones being entirely of the false-net type. The same results were obtained with water having a pH about 4.8, the pH being adjusted with a one-tenth normal solution of phosphoric acid. A few *Achlya* sporangia were obtained when ordinary sterile distilled water was used, if the water was changed several times. Under ordinary culture methods, no *Achlya* sporangia are ever formed.

This winter (1931) a form of this species has been collected in which the number of *Achlya* sporangia is greater, under the same cultural conditions, than in the above form.

The same experiments were carried out on *D. missouriensis* with similar results. These observations suggest a very close relationship between *Dictyuchus* and *Achlya*.

Similar tests were made with several strains of *Dictyuchus monosporus*, but in none were any sporangia except of the true-net type formed. Numerous trials were made to bring about a crossing between this species and the heterothallic strains of *D. monosporus* but without any success.

Dictyuchus achlyoides Coker and Alexander. (This Journal **42**: 218, pl. 36. 1927).

Under ordinary culture conditions the early sporangia are of the *Achlya* type, the later ones are of the false-net type and are much more abundant than the first type. The plant differs from both the other species of the false-net group in having strongly papillate oogonial walls and also in that the early sporangia of this species are normally mostly of the *Achlya* type. This species also forms gemmae in great abundance in very old cultures, a characteristic which also helps distinguish this from the other two plants. This species approaches *Brevilegnia bispora* in sporangial characters, but can be separated from that genus by its more extensive mycelium and larger oogonia and eggs.

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CHAPEL HILL, N. C.

EXPLANATION OF PLATE 15

(The plate was inked in by Miss Alma Holland)

DICTYUCHUS MISSOURIENSIS

FIG. 1. Habit sketches of sporangia and oogonia. × 127.

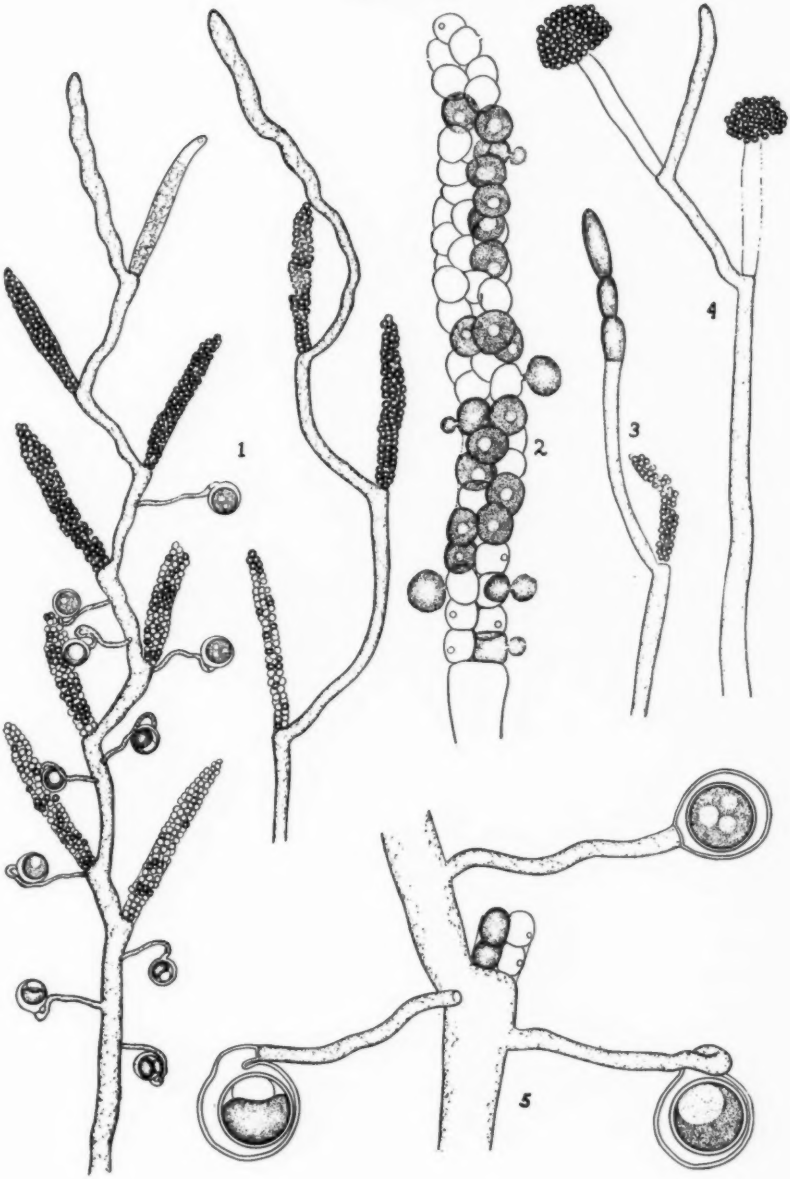
FIG. 2. Enlarged view of sporangium, the wall of which has mostly disappeared. The spores are emerging from their cysts, leaving a false net. × 487.

FIG. 3. Sporangium showing disintegrating wall and gemmae. × 127.

FIG. 4. Sporangia of the *Achyla* type. × 127

FIG. 5. Oogonia. × 414.

PLATE 15



MICROMYCES ZYGOGONII DANG., PARASITIC ON SPIROGYRA

By JOHN N. COUCH*

PLATES 16–18

The genus *Micromyces* was founded by Dangeard in 1888 on a single species, *M. Zygogonii*, found in the cells of the alga *Zygogonium*, and in a later paper he ('91) added some new facts to his earlier observations. Apparently the same species has been found on *Spirogyra* growing in a lake in southwestern France by Denis ('26). Several other species have been reported, but since none of these has been adequately described the taxonomic position of the genus is still in doubt (Fischer '92; Minden '11; Fitzpatrick '30). In the late summer of 1925 I collected a parasite on *Spirogyra* sp. which except for certain minor details appears to be the same as *M. Zygogonii* Dang., and since the material was abundant and nearly all stages of development were represented, I believe that the following account of this species will serve to clear up the doubtful position of the genus.

MICROMYCES ZYGOGONII DANG.

Thallus at first a naked, amoeboid, plasma body within the algal cell. At length coming to rest next to the nucleus of the host and growing at the expense of the latter; forming at maturity a more or less spherical body, the prosorus, which contains a single large nucleus up to 8μ thick. Prosori 10–33.6μ thick, most about 21μ thick. Covered by a hyaline, spiny membrane or rarely the membrane may be nearly smooth. Spines up to 22μ long, most about 12μ long. The number of spines varies from about 12–24. Membrane irregularly reticulated between the spines. The prosorus may germinate directly, discharging its contents into a vesicle, the contents of which now cleave into from about 8 to 24 or even more sporangia. Sorus globose or ovoid, remaining attached to the empty prosorus until after the sporangia are formed, and then losing its shape more or less completely by the swelling and bursting apart of the sporangia. Sporangia usually polygonal in shape, about 8.4 x

*The observations on this plant were made while the writer was a National Research Fellow.

9.6μ thick in its two greatest dimensions; sometimes pyramidal in shape, but with a rounded base and a truncated apex. The contents of the sporangia quickly divide into many, very small, uniciliate zoospores. Zoospores subglobose or ovoid with a glistening droplet at one or both ends, about 1μ thick. Planogametes (?) also formed which apparently fuse to form zygotes. The thallus may become transformed into a pale yellowish brown and thick-walled, uninucleate resting body, which is covered with a hyaline spiny membrane; resting bodies 16–21μ thick; discharging their contents into a vesicle. The contents later perhaps cleave to form sporangia.

Found in the cells of *Spirogyra* sp. in a small pond near Cold Spring Harbor, L. I., N. Y., August 7, 1925. The species of *Spirogyra* appears to be near *S. adnata*, but since the alga was only in the vegetative condition, I could not be sure of its identity. The cells measured 37–44 x 147–190μ; without replicate ends. Chlorophyll bands 3 or 4 making about 2 complete turns. In the same material there was another species of *Spirogyra*, slightly smaller and with only one chlorophyll band. This species was entirely untouched by the parasite.

DEVELOPMENT OF THE FUNGUS

In the development of this parasite there are several noteworthy points. Shortly after the spore has come to rest on the surface of the *Spirogyra* cell one notices a slight swelling of the wall just beneath the parasite and next one may notice the latter passing slowly through a fine pore in the swollen part of the wall (fig. 7). The parasite apparently first softens the host wall and then pushes through a fine filament to make a passage way through which the minute amoeboid cell now flows.

Within the host, the amoeboid cell moves toward the nucleus (fig. 7, *par*) and almost invariably becomes closely appressed to the latter. The number of parasitic bodies which enter one cell is usually one or two but in some cases the number may be so numerous that only part of them can be in direct contact with the nucleus (fig. 13). Where there is only one or a few parasites in the cell and ample space is left for these to get in contact with the host nucleus, I have observed only a few parasites which developed not in contact with the host nucleus.

The infecting spore is uninucleate and the thallus which develops from it remains uninucleate until after maturity and just before sporangial formation. As it increases in size the nucleus also grows and the latter can be made quite conspicuous by the addition of a weak solution of

methylene blue either to fresh material or to material preserved in glycerine.

The parasite increases in size, actually appearing to usurp the position of the host nucleus. The delicate strands of protoplasm which held the latter in its central position in the cell and which connected it with the pyrenoids are gradually broken and similar strands may be observed to pass from the body of the parasite out to various parts of the host cell. Most of these strands connect the parasite with pyrenoids (figs. 9–12, c) while others extend out into the host cytoplasm. The strands which pass out into the cytoplasm often have their ends more or less surrounded by the streaming cytoplasm of the host (fig. 11 s). At this stage of development the thallus is composed of two distinct zones: an inner dense and an outer hyaline region. As the parasite matures the thallus assumes a rounded form, the strands of cytoplasm lose their granular appearance and assume the form of more or less rigid and straight hyaline spines (figs. 11, 15).

After a short period of rest, during which time the diseased host cell has more or less completely disintegrated, the mature thallus may become transformed into a prosorus. The contents of the prosorus are discharged into a thin vesicle (fig. 17). At this stage the single large nucleus has already divided forming a large number of small nuclei. In *Synchytrium endobioticum*, Curtis (1921) describes nuclear division as taking place after the discharge of the prosorus into the vesicle and it is very likely that the same sequence of events occurs here. The contents of the vesicle are then cut up into from eight to twenty-four sporangia (figs. 18–21). The nuclei in the sporangia undergo division until large numbers of very minute nuclei are formed. The mature spore is uninucleate, exceedingly minute, and is equipped with one cilium (figs. 20, 21). The sorus of sporangia is subglobose or ovoid in shape but retains its shape for only a short while. The sporangia absorb water and swell, bursting the wall of the sorus, and become more or less separated from each other, forming a loose irregular mass (figs. 20, 21). Sometimes the wall of the sorus resists the swelling and the spores may then be discharged from the sporangia, leaving a sorus composed of empty sporangia (fig. 19). The sporangia are sometimes shaped like a truncated pyramid rounded at the base (fig. 22) though the shape may vary considerably.

I have not observed the discharge of the spores and their subsequent behavior in the living condition. In my preserved material which was killed on the slides and has remained intact, there are many sporangia

from which the spores were in the act of emerging when the material was killed (figs. 20, 21). A considerable number of spores were also seen in close proximity to the groups of partially empty sporangia. A number of the minute spores were seen apparently in the act of fusing (figs. 20, 22). A few biciliate spores were seen which were approximately double the size of the uniciliate ones. It seems very probable that the condition here is the same as that described by Curtis (1921) in *Synchytrium endobioticum*; that, in addition to zoospores, planogametes are also formed which fuse to form a zygote. According to Curtis (1921) both swarm spores and zygotes are capable of reinfecting the host, the former developing into other prosori while the latter develop into resting sporangia. The same condition seems to exist here, since I have found both the minute zoospores and the larger bodies (zygotes?) penetrating the host cell. I have not followed their subsequent development on living material and am therefore unable to say if the swarmspores develop only into prosori and the zygotes only form resting bodies.

The resting bodies are formed in large numbers and when mature can be easily distinguished from the prosori by the smaller size of the resting bodies, distinctly thicker wall and by the fact that this wall is colored a pale yellowish brown. In some of the resting bodies a small, eccentric, elliptic globule may be seen. I have found only one resting spore germinating. This was discharging its contents through a minute pore into a thin vesicle (fig. 25). It is probable that the other stages in the germination of the resting spores are similar to those described in the germination of a prosorus.

It is only by the time the prosorus has about reached maturity that the host cell shows signs of its diseased condition. The chlorophyll bands have become thinner and shorter and the pyrenoids have all but disappeared (figs. 13, 14, 15). If the pyrenoids are tested for starch at this period, one gets only a very faint starch reaction. The host nucleus almost invariably remains firmly attached to the parasitic body even after the remainder of the *Spirogyra* cell has disintegrated (fig. 15–19 and 23–25). Dangeard ('88, '91) noticed that the cells of *Zygogonium* which were infected with *M. Zygogonii* swelled to more than twice their normal diameter and Denis ('26), who found the same parasite on *Spirogyra quadrata*, observed that the parasitized cells were abnormally swollen. Denis further noted that the reserve starch in the pyrenoids was used up by the parasite and that the chloroplasts and nucleus became disorganized.

Why the parasite goes to the nucleus instead of settling down for its

development in other parts of the cell is an extremely interesting subject for speculation. The nucleus has been considered by some (Sharp, l. c., p. 93) as the center of oxidation activities and as such it might offer an attraction to the parasite. The nucleus is centrally located and is connected with the pyrenoids by delicate cytoplasmic strands. The parasite appears to grow mostly at the expense of the food stored in the pyrenoids, and the position of the nucleus is certainly the most centrally located one for drawing on this food supply. In this connection it is interesting to note that in *S. endobioticum* the position of the parasite in the host cell is determined by the streaming of the host cytoplasm which carries the infecting body to the bottom of the host cell (Curtis '21). One of her figures also shows the parasitic body in contact with the host nucleus.

In my material a considerable number of the nearly mature prosori as well as resting bodies may become parasitized by a peculiar protozoan (fig. 26, p.). This protozoan develops within the cell of *Micromyces*, finally emerging in large numbers, each one as a small (about 4–5μ thick), flagellated body. After all of the parasitic bodies have emerged, a very delicate, empty network is all that remains of the contents of the parasitized prosorus or resting body (fig. 26).

TAXONOMIC POSITION OF THE FUNGUS

The following is taken from Dangeard's two accounts of the genus *Micromyces* as based on the single species *M. Zygogonii*. The genus is characterized by its minuteness. Dangeard does not give any measurements, but Denis ('26) states that the prosori are about 20μ thick. The nearly mature thallus is differentiated into an outer hyaline region and an inner denser zone. The thallus is uninucleate and though Dangeard states that the nucleus is small, his figures 8 and 10 ('88) show a nucleus of considerable size compared with the thallus. The prosorus becomes invested with a spiny membrane. When mature, the contents of the prosorus are discharged into a thin-walled vesicle (Dangeard '91, figure 3). The large nucleus now divides and by repeated division several smaller nuclei are formed. The contents of the vesicle are then cut up into a sorus of 3–7 sporangia. Denis ('26) states that there are many sporangia. The sporangia may then burst apart into a loose mass (Dangeard '91, figs. 2, 5), or they may become only slightly separated so that the sorus partly retains its shape (Dangeard '88, figs. 4, 5, 6 and '91, fig. 4). The swarmspores are numerous and very minute. Their fate after discharge is not known. The resting spores are fur-

nished with a thick, brown colored, spiny, warted or smooth membrane (Dangeard '88, figs. 7, 9).

By putting together Dangeard's ('88, '91) two accounts it is possible to form a rather clear picture of the structure and development of his plant, but some of his figures are difficult to understand. In fig. 3 ('91) he shows the contents of the prosorus discharged as an elongated, bent mass of protoplasm. If such an irregular mass of protoplasm should segment to form a sorus of sporangia, it would indeed be a peculiar condition. It is possible that this irregular mass is nothing but part of the collapsed protoplast of the host. In figure 2 ('91) he figures only parts of the sporangial walls, as though the other parts had dissolved to set free the spores.

From the available facts it is clear that Dangeard's species and mine are the same. The fact that one grows in *Zygogonium* and sometimes in *Spirogyra*; the other in *Spirogyra*, both genera of the Conjugatae, suggests a relationship. Dangeard's form differs from mine in the following ways: the spines on the prosori and resting bodies of the former are shorter; the prosori are smaller; and the number of sporangia produced in each sorus is fewer than in the American form. The two forms also show a difference in their effect on the host: the forms studied by Dangeard and Denis cause a distinct swelling of the host whether growing in *Zygogonium* or *Spirogyra*. It is likely, however, that this is not a significant difference, since the present form parasitizes a rather large species of *Spirogyra*, the cells of which afford ample space for the development of the parasite, whereas the form described by Dangeard lives in smaller algae. The other species of *Micromyces* with which the present species must be compared is *Micromyces Spirogyrae* Skvortzow ('27). The following is a translation from the German of Skvortzow's description: "Two or three [thalli] in the zygotes of *Spirogyra*. Resting spores with a thick, brownish, smooth membrane, 8–12.9μ thick. Swarmspores unknown. In a bog; Amoy, South China." This may or may not be a species of *Micromyces*; it is apparently distinct from the present species.

In comparison with *Micromyces* the prosori and resting bodies of *Synchytrium* are much larger, reaching a maximum size in the former genus of 33.6μ and in the latter of 180μ or even more. In *Synchytrium* the prosori and resting spores are seldom if ever spiny. The resting spores, however, are often covered with a thick, warted membrane or the membrane may be coarsely reticulated as in *S. endobioticum* or *S. saxifragae*. The prosorus contains a single large nucleus which in *S.*

endobioticum attains the enormous diameter of 25μ. The nucleus in the prosorus of the present species of *Micromyces* is 8μ thick, a comparatively large nucleus for such a small thallus. In the subgenus *Mesochytrium* a thin-walled vesicle is extruded from the prosorus and the protoplasm flows into this and is then delimited into sporangia. In *Micromyces Zygogonii* the sorus is formed in precisely the same way. The number of sporangia contained in one sorus in *Synchytrium* is often up to 100 or even more, rarely only 5–10 (*S. endobioticum*). In *Micromyces* the number varies from 3–24. The swarmspores are uniciliate and vary from 3–6μ thick; in *Micromyces* they are about 1μ thick. Curtis (1921) has shown that in addition to swarmspores gametes are also formed which fuse in pairs to form a biciliate zygote and that from this zygote the resting spore is formed. The gametes except for their behavior are indistinguishable from the swarmspores. In the species of *Micromyces* here described I have found an apparent fusion of gametes similar to that described by Curtis. In short the cytology and development of the present species of *Micromyces* and *Synchytrium*, as illustrated by *S. endobioticum*, are strikingly similar. But in view of the slight morphological differences between the two genera and the great difference in size correlated with a striking difference in habitat it seems best to retain the genus *Micromyces* rather than to merge it with the subgenus *Mesochytrium*.

SUMMARY

Micromyces Zygogonii Dang. is described for the first time from the western hemisphere. The parasite enters the *Spirogyra* cell by softening the wall and then making a fine hole in the wall through which it flows. The parasite becomes closely appressed to the nucleus and develops primarily at the expense of the pyrenoids. The young thallus is uninucleate and remains so until after maturity. The nucleus is very large and conspicuous. At maturity the thallus functions as a prosorus discharging its contents into a thin-walled vesicle in which the sporangia are delimited. Very minute, uniciliate, swarmspores and gametes (?) are formed, the latter apparently fusing to form zygotes. Thick-walled, uninucleate resting spores are also formed.

By a comparison of the structure, development, and habitat the species is evidently the same as *M. Zygogonii* Dang. By comparing the cytology and development of the present species with *S. endobioticum* it is seen that there are striking similarities between the two, and it may be concluded that the genus *Micromyces* is correctly placed in the family *Synchytriaceae*.

nished with a thick, brown colored, spiny, warted or smooth membrane (Dangeard '88, figs. 7, 9).

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From the available facts it is clear that Dangeard's species and mine are the same. The fact that one grows in *Zygogonium* and sometimes in *Spirogyra*; the other in *Spirogyra*, both genera of the Conjugatae, suggests a relationship. Dangeard's form differs from mine in the following ways: the spines on the prosori and resting bodies of the former are shorter; the prosori are smaller; and the number of sporangia produced in each sorus is fewer than in the American form. The two forms also show a difference in their effect on the host: the forms studied by Dangeard and Denis cause a distinct swelling of the host whether growing in *Zygogonium* or *Spirogyra*. It is likely, however, that this is not a significant difference, since the present form parasitizes a rather large species of *Spirogyra*, the cells of which afford ample space for the development of the parasite, whereas the form described by Dangeard lives in smaller algae. The other species of *Micromyces* with which the present species must be compared is *Micromyces Spirogyrae* Skvortzow ('27). The following is a translation from the German of Skvortzow's description: "Two or three [thalli] in the zygotes of *Spirogyra*. Resting spores with a thick, brownish, smooth membrane, 8–12.9μ thick. Swarmspores unknown. In a bog; Amoy, South China." This may or may not be a species of *Micromyces*; it is apparently distinct from the present species.

In comparison with *Micromyces* the prosori and resting bodies of *Synchytrium* are much larger, reaching a maximum size in the former genus of 33.6μ and in the latter of 180μ or even more. In *Synchytrium* the prosori and resting spores are seldom if ever spiny. The resting spores, however, are often covered with a thick, warted membrane or the membrane may be coarsely reticulated as in *S. endobioticum* or *S. saxifragae*. The prosorus contains a single large nucleus which in *S.*

endobioticum attains the enormous diameter of 25μ. The nucleus in the prosorus of the present species of *Micromyces* is 8μ thick, a comparatively large nucleus for such a small thallus. In the subgenus *Mesochytrium* a thin-walled vesicle is extruded from the prosorus and the protoplasm flows into this and is then delimited into sporangia. In *Micromyces Zygogonii* the sorus is formed in precisely the same way. The number of sporangia contained in one sorus in *Synchytrium* is often up to 100 or even more, rarely only 5–10 (*S. endobioticum*). In *Micromyces* the number varies from 3–24. The swarmspores are uniciliate and vary from 3–6μ thick; in *Micromyces* they are about 1μ thick. Curtis (1921) has shown that in addition to swarmspores gametes are also formed which fuse in pairs to form a biciliate zygote and that from this zygote the resting spore is formed. The gametes except for their behavior are indistinguishable from the swarmspores. In the species of *Micromyces* here described I have found an apparent fusion of gametes similar to that described by Curtis. In short the cytology and development of the present species of *Micromyces* and *Synchytrium*, as illustrated by *S. endobioticum*, are strikingly similar. But in view of the slight morphological differences between the two genera and the great difference in size correlated with a striking difference in habitat it seems best to retain the genus *Micromyces* rather than to merge it with the subgenus *Mesochytrium*.

SUMMARY

Micromyces Zygogonii Dang. is described for the first time from the western hemisphere. The parasite enters the *Spirogyra* cell by softening the wall and then making a fine hole in the wall through which it flows. The parasite becomes closely appressed to the nucleus and develops primarily at the expense of the pyrenoids. The young thallus is uninucleate and remains so until after maturity. The nucleus is very large and conspicuous. At maturity the thallus functions as a prosorus discharging its contents into a thin-walled vesicle in which the sporangia are delimited. Very minute, uniciliate, swarmspores and gametes (?) are formed, the latter apparently fusing to form zygotes. Thick-walled, uninucleate resting spores are also formed.

By a comparison of the structure, development, and habitat the species is evidently the same as *M. Zygogonii* Dang. By comparing the cytology and development of the present species with *S. endobioticum* it is seen that there are striking similarities between the two, and it may be concluded that the genus *Micromyces* is correctly placed in the family *Synchytriaceae*.

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EXPLANATION OF PLATES 16–18

Figures 1–5, photographs; others with the aid of a camera lucida.

PLATE 16

Fig. 1. Non-parasitized cells of *Spirogyra* sp. ×250.

Fig. 2. Filament of *Spirogyra* showing one or more parasites (*Micromyces Zygogonii* Dang.) in every cell. Note the parasites in all cells are next to the nucleus. The cell next to the right in the long thread contains a disintegrated sorus. ×70.

Figs. 3, 4, 5. Showing three parasitized cells. In figure 5 the lower parasitic body is a resting spore on which a thick wall is evident in addition to the spiny membrane. The other parasitic bodies are prosori. ×250.

PLATE 17

Fig. 6. Healthy cell of *Spirogyra*. ×414.

Fig. 7. Showing zygote (?) of parasite passing through host wall, also another parasite already within the host cell making its way toward the nucleus. ×834.

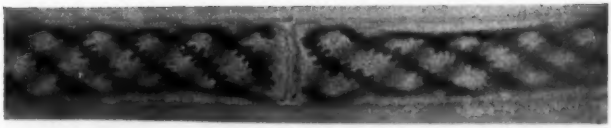
Fig. 8. Showing young parasite (*par*) applied to host nucleus (*h n*). ×834.

Fig. 9. As in fig. 8 except parasite has increased in size considerably and has one protoplasmic connection (*c*) with a pyrenoid. ×834.

Fig. 10. Showing two parasites applied to host nucleus. ×834.

Figs. 11, 12. Nearly mature thalli of parasites applied to host nuclei. Note the conspicuous nuclei in the parasites (*p n*). ×834.

PLATE 16



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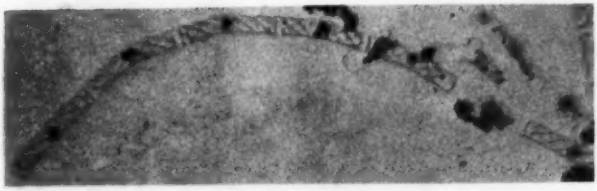

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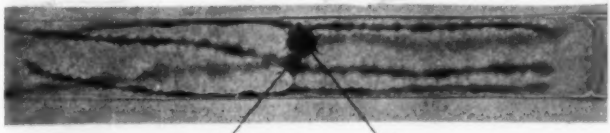

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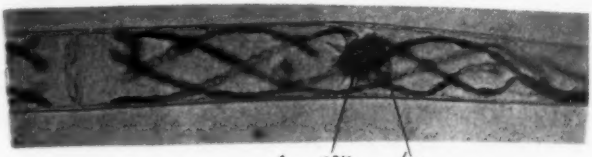

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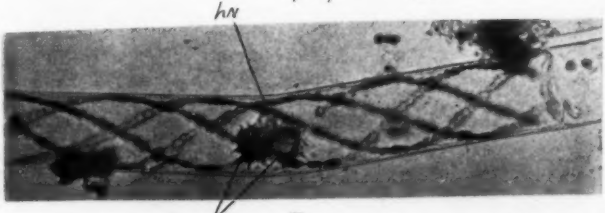

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PLATE 17

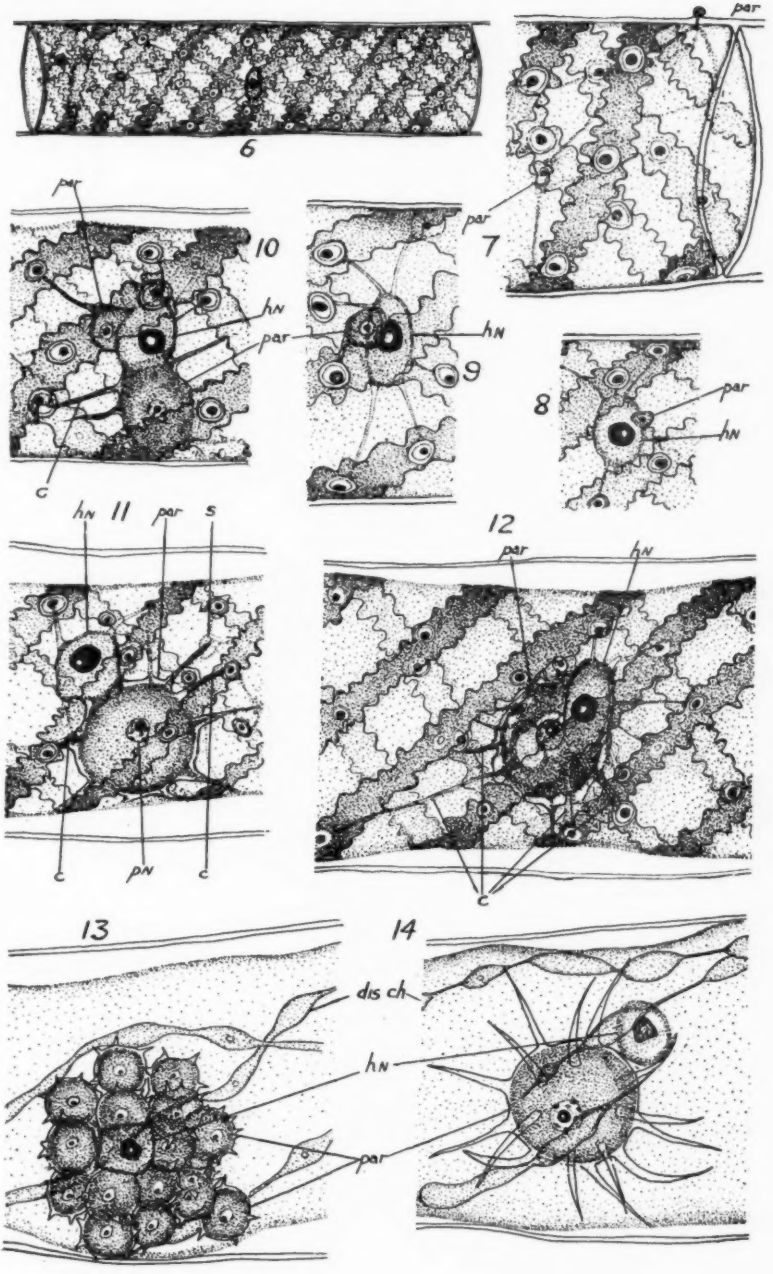
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PLATE 18

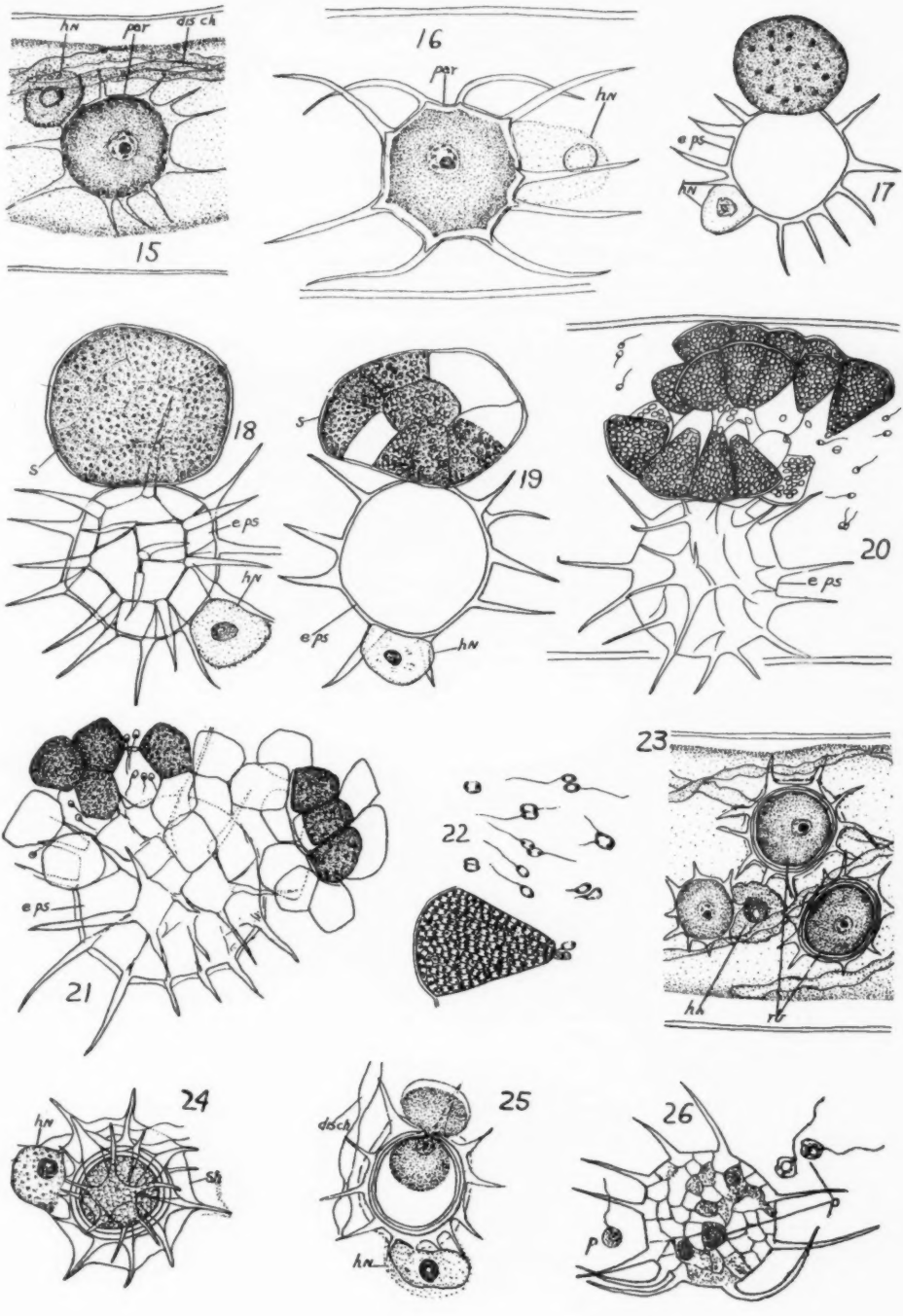
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Fig. 13. Showing 16 or more parasites developing in one *Spirogyra* cell. Note old nucleus of *Spirogyra* surrounded by parasitic bodies. Chloroplasts are disintegrating and pyrenoids have almost disappeared. ×834.

Fig. 14. Nearly mature prosorus with conspicuous nucleus and spiny membrane. Combined surface and section view. Note host nucleus. ×834.

PLATE 18

Fig. 15. Prosorus with host nucleus. ×834.

Fig. 16. Prosorus with extra long spines. Protoplasm considerably collapsed from wall. Note host nucleus. ×834.

In figs. 17–19, 21–22, 24–26 the more or less disintegrated *Spirogyra* walls are not shown, in order to save space.

Fig. 17. Prosorus just after emptying contents into vesicle to form young sorus. A number of smaller nuclei have been formed from large nucleus. ×834.

Fig. 18. Sorus in process of cleavage to form sporangia. Small dots represent nuclei. ×834.

Fig. 19. Sorus of sporangia which have not burst apart. Three empty sporangia shown. ×834.

Fig. 20. Sorus with many sporangia, several of which are discharging spores and several are empty. Note spores and gametes (?). ×834.

Fig. 21. Large group of sporangia, most of which are empty. ×834.

Fig. 22. Spores emerging from sporangium. Gametes (?) in process of fusing. ×1600.

Fig. 23. Spirogyra cell with two mature (*r b*) and one immature resting body. ×834.

Fig. 24. Combined surface and section view of resting body showing two layered wall, spiny membrane and a sheath (*sh*) over this. ×834.

Fig. 25. Resting body in process of germination. Note vesicle from which protoplasm has partly collapsed. ×834.

Fig. 26. Prosorus parasitized by protozoan (*p*). Note inconspicuous net-like structures in nearly empty prosorus. ×834.

NOTES ON FRESH-WATER SPONGES AND THEIR EPITHELIOID MEMBRANES

By J. T. Penney

Plate 19

A preliminary survey of the ponds and streams immediately around Columbia, South Carolina, indicates that sponges are probably quite abundant. In one pond alone, four different forms have been collected. This pond (Horseshoe pond), which is only three miles from the biological laboratory of the University and on a main highway, is fed by bottom springs. It has no outlet. The size of the pond varies somewhat with the seasons, but it always covers several acres. It is very shallow around the edges and gradually slopes to a depth of six or seven feet near the center. The bottom is sandy and the water is clear. Many water plants are found in the shallow region. No collections have been taken from the deeper parts.

Of the four species of sponges collected, two have been identified: (1) *Tubella pennsylvanica*, Potts and (2) *Heteromeyenia ryderi*, var. *baleni*, Potts. The third one is an unidentified species of Spongilla and the fourth is one which has not yet been found with gemmules. In addition to these sponges from the Columbia region, *Heteromeyenia ryderi* from Chapel Hill, North Carolina, is reported. According to information available, only one fresh-water sponge, *Trochospongilla horrida* (Gee, '26) has been reported from South Carolina.

Tubella pennsylvanica, Potts

This sponge is green when growing in the light; gray to white when not. It is encrusting, reaching a thickness in the largest specimens of not more than one fourth of an inch. There is quite a range in size. Many are very small, while a typical one bearing gemmules is three and one fourth inches long and in places completely surrounds a stick which is three fourths of an inch in diameter. The sponge is found on dead sticks and stumps in shallow water.

Dermal spicules are not present.

Gemmules, when present, are abundant, forming a dense layer at the base of the sponge. Their brown color is in sharp contrast with the green color of the sponge. They average 400μ in diameter. The granular crust is 40μ thick and is charged with a single layer of inaequibirotulates, the inner and larger rotules of which rest upon the chitinous coat of the gemmule. These spicules (fig. 1, *a*, *a'*) occupy less than half the width of the granular crust. They range in length from 10.4 to 17.6μ. The inner rotule ranges from 12.8 to 19.6μ in diameter and the smaller one ranges from 3.2 to 6.4μ in diameter. The margins of both rotules are entire but often irregularly circular (fig. 1, *a'*). The margin of the larger rotule is slightly turned up (saucer like) in the direction of the smaller rotule. The shafts near the central part are from 1.5 to 2μ in diameter, but they become slightly expanded as they approach the larger rotule.

The skeletal spicules are spined. There are two types of these spicules present, one of which has pointed, and the other rounded, ends (fig. 1; *c*, *c'*). Both types have the same range in size: 118 to 246.4μ by 3.2 to 6.4μ. Spicules of both types are closely applied to the outside of the granular crust of the gemmule, but here they range in size from 118 to 144.8μ by 3.2 to 6.4μ.

In addition to the above a very few slightly curved aequibirotulates (fig. 1; *b*), each rotule consisting of several incurved hooks, were found in the spicule preparations of one specimen. A careful search for these spicules in preparations of the dermal membrane, in sections through the sponge, and in sections through many gemmules failed to reveal them. These same spicules are, however, present as dermal spicules in the sponge referred to above (p. 240) as unidentified because of the absence of gemmules. Since these two sponges occur in the same places it is altogether probable that some of the dermal spicules of the unknown sponge were deposited in the Tubella specimen.

Tubella has been collected in the same pond throughout the year. Those containing gemmules were first collected December 3, 1929, and as late as March 1, 1930.

This description agrees in all the essential points with that of Potts ('87). He describes Tubella as minute and states that the first specimen (containing gemmules) was about one fourth of an inch in diameter while all the specimens containing gemmules that I have collected have been quite large (see above). Potts gives only one measurement for each type of spicule, but with the exception of the length of the inaequibirotulates all of these measurements are within the limits recorded

above. According to his account the gemmule spicules are much shorter than the ones described here while the diameter of the rotules is about the same. These variations are to be expected in such a widespread species. According to Smith ('21) *Tubella pennsylvanica* has been reported from seven states (Florida the only southern state), New Foundland, Nova Scotia, Europe, and Asia.

Most all of these sponges were growing in the light and apparently quite healthy. Annandale ('09), however, states in reference to the same species that "It appears, wherever it occurs, to be averse to light and to be found as a rule under stones or roots."

HETEREOMEYENIA RYDERI, V. BALENI, POTTS

This sponge is green and massive, a typical specimen measuring four inches in length by two inches in the thickest portions. It is commonly found on the stems and leaves of living water plants in shallow water. It is roughly divided into lobes. The texture is loose.

No dermal spicules are present.

The gemmules are abundant and are scattered throughout the body of the sponge. They average 480μ in diameter. The granular crust is 52μ thick and is charged with two distinct types of aequibirotulates, both of which rest by one rotule on the chitinous coat. One type is much longer than the other. The short type has deeply serrate rotules (fig. 2; *a'*, *b*). The central outer part of each rotule appears as a short rounded projection. The shafts of these spicules are smooth. This type ranges in length from 23.5 to 52μ. The diameter of the shaft is a little less than 2μ. The diameter of the rotules is 13.7μ. All the spicules of this type lie within the granular crust. The long type of gemmule spicule projects outside the granular crust. They are far less abundant than the spicules of the short type. The rotules consist of a few (generally 4) incurved hooks. The shafts bear one or two short spines near the center (fig. 2; *a*). These spicules range in length from 50.9 to 78.4μ. The diameter of the shaft is a little less than 2μ. The diameter of the rotules is 10.7μ.

Skeletal spicules are slender, spined, and acuminate. They range in size from 145 to 270.5μ by 1.96 to 6.8μ.

This sponge is also perennial. Specimens containing gemmules have been collected from December to March. Crowell ('26) has collected gemmule bearing sponges of this species from August 10 to February 1.

This description agrees in all the essentials with that given by Potts ('87). The only variation of any importance is that the rotules of the

short type of gemmule spicule are more deeply serrate than those figured by Potts ('87, Pl. XI, fig. 4). Potts reports this variety from New Jersey and Florida. Smith ('21) does not list this variety, but does list the species as having been reported from eleven states, Nova Scotia, and Europe.

HETEROMEYENIA RYDERI, POTTS

I have collected gemmule bearing specimens of *Heteromeyenia ryderi* from Bolings Creek, Chapel Hill, North Carolina. They were found as encrustations on stones in fairly rapid water. As compared with the variety from Columbia they are very small. The largest ones collected measured an inch and a half by one inch.

Dermal spicules are not present.

The gemmules are abundant, when present, and are scattered throughout the sponge. They are 400μ in diameter. The granular crust is 23.5μ thick and is charged with two distinct types of aequibirotulates. One type which is in the minority is much longer than the other and projects outside the granular crust. The rotules of the long type consist of from 3 to 6 incurved hooks. The shafts bear many spines which are just as long as the rays of the rotules (fig. 3; *a*). A typical spicule of this type measures 47μ x 4.9μ. The diameter of the rotules is 15.6μ. The second or short type of spicule (fig. 3; *b*, *b'*) extends the whole width of the granular crust. The shafts are expanded at each rotule. They may bear one or two small spines. The margins of the rotules are serrate but not as deeply so as in the variety described above. A typical spicule measures 23.5 x 3.9μ.

The skeletal spicules are robust and spined except at their pointed ends (fig. 3; *c*). A typical one measures 160 x 12μ. The data as to the time of occurrence of the gemmules are lacking.

This description agrees with the type description given by Potts ('87) as far as gemmular and skeletal spicules are concerned. The only variations are minor ones such as size of the sponge and thickness of the granular crust.

EPITHELIOID MEMBRANES

Wilson ('10) describes the epidermis of Stylotella as a thin sheet of protoplasm studded with nuclei and showing no cell boundaries. Wilson and Penney ('30) report the same thing for the epidermis and the epithelioid lining of the canals of Microciona. The same kind of epithelioid

membrane is here described for *Tubella pennsylvanica*, *Heteromeyenia ryderi*, var. *baleni*, and for the unidentified Spongilla.

Shreds of the dermal membrane were peeled from the sponge, stained, and mounted in balsam. Good areas, unobscured by underlying cells were found at the margins of these shreds. Paraffin sections tangential to the surface of the sponge yielded excellent thin flat areas. A very satisfactory method for studying the epidermis in the living sponge was carried out as follows: Healthy specimens were placed on glass slides at the bottom of large glass dishes of pond water. When specimens growing on plants were used it was necessary to tie the plant to the slide with thread, otherwise it would float. The sponge soon became attached to the slide (generally overnight) and grew out as a thin encrustation. The bulky part was then cut away without injury to the thin portions. The preparation was then covered and studied with the oil immersion objective. Fixed preparations made this way are excellent.

Two fixing fluids, Bouin and absolute alcohol were used. Both were very good. Several stains were used but the best results were obtained with Delafield's haematoxylin followed by either Orange G or acid fuchsin. A good clean stain was obtained in all cases. Paraffin sections tangential to the surface of specimens treated by the silver nitrate reduction method were also studied.

The epidermis of all three sponges is a continuous sheet of protoplasm with irregularly placed nuclei. The portion of the epidermis figured (fig. 4) and described is from *Tubella pennsylvanica*. Cell boundaries are not present. Many preparations, showing large flat thin areas unobscured by underlying cells, were studied. The silver nitrate material shows no structures that could in the least be confused with cell outlines. The majority of the nuclei are ellipsoidal although an occasional one that is circular in outline is found. These nuclei measure 6 x 4μ. They contain several coarse granules no one of which is more conspicuous than the other. The internuclear areas show a granular reticulum, the meshes of which vary considerably in size. The granules of this reticulum stain well with either orange G or acid fuchsin. The epidermal lines described by Wilson and Penney ('30) for the epidermis of Microciona were not observed here. They were looked for in preparations of the living sponge and in all types of fixed preparations.

The epithelioid lining of the canals was studied in only two sponges: *Tubella pennsylvanica* and the unidentified Spongilla. Large thin areas were obtained. The structure is the same as that of the epidermis (fig. 5) with the exception, of course, that no pores are present.

SUMMARY

Tubella pennsylvanica, Potts; *Heteromeyenia ryderi*, var. *baleni;* and an unidentified species of Spongilla, all from South Carolina, and *Heteromeyenia ryderi*, Potts from North Carolina are reported.

The epithelioid membranes of the three sponges from South Carolina are continuous sheets of protoplasm with irregularly placed nuclei and no cell boundaries.

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EXPLANATION OF FIGURES ON PLATE 19

1. Tubella pennsylvanica, Potts. *a*, *a'*, gemmule spicule; *b*, aequibirotulate (probably from another sponge); *c*, *c'*, skeletal spicules. ×660.

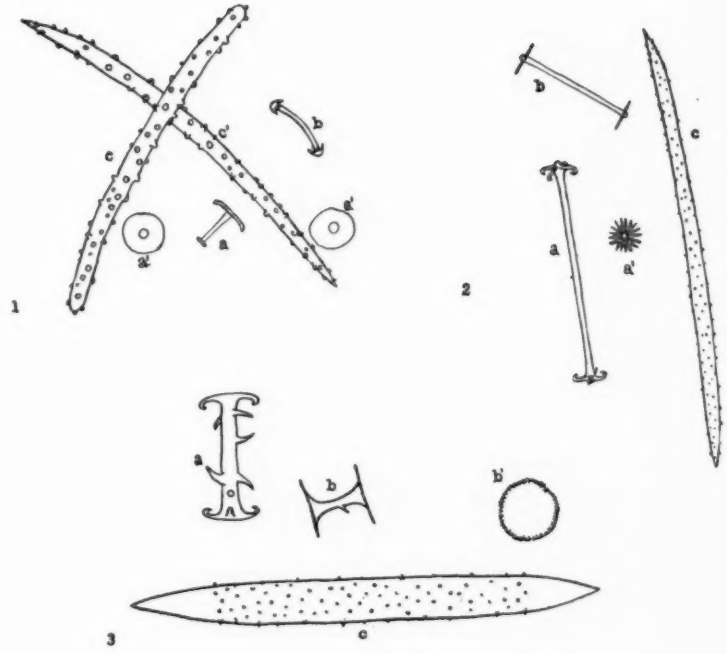
2. Heteromeyenia ryderi, var. baleni, Potts. *a*, long type gemmule spicule; *a'*, end view of short type gemmule spicule; *b*, short type spicule; *c*, skeletal spicule. ×660.

3. Heteromeyenia ryderi, Potts. *a*, long type gemmule spicule; *b*, short type gemmule spicule; *b'*, short type spicule, end view; *c*, skeletal spicule. ×660.

4. Epidermis of Tubella pennsylvanica. From a tangential section of the mature sponge. Bouin, Delafield's haematoxylin and acid fuchsin. *p*, pores. ×1525.

5. Epithelioid lining of canal. From a paraffin section of the mature sponge. Bouin, Delafield's haematoxylin and acid fuchsin. ×1525.

PLATE 19



NEW CAVERNICOLE CARABIDÆ OF THE SUBFAMILY TRECHINÆ JEANNEL

By J. Manson Valentine

Plates 20–22

For some time the writer has been endeavoring to decide upon a small group of carabid beetles which might lend itself well to monographic work involving investigations into the following: (1) taxonomy, (2) interspecific differences, (3) evolution of species as affected by isolation, (4) adaptation to a circumscribed environment, (5) parallelism, (6) dispersal in the face of extreme difficulty. Inspired by the recent splendid monograph of World *Trechinæ* by Dr. R. Jeannel, the writer lost no time in selecting the little known American cavernicole carabids with an eye to an initial consideration of the subterranean forms of the group *Trechinæ*.

The following paper is designed as a preliminary report of the results of two short trips into hitherto unworked cavernous districts of the southern Appalachian limestone system. It includes brief diagnostic descriptions of 10 new species and 1 new subspecies of anophthalmid *Trechinæ*. These are illustrated by original line drawings. It is sincerely hoped that the paper may serve as an incentive to coöperative work on the part of collectors living in the neighborhood of limestone caverns, in order that much more data may be assembled regarding these important yet neglected forms.

Success in collecting anophthalmid beetles requires a little knowledge of the favorite haunts of these insects. Dry or excessively frequented caverns are very unproductive unless one can find undisturbed nooks in which there is running or dripping water. An important result of a recent trip, during the course of which sixteen caves were visited, has been the determination of the optimum conditions for discovery when the cave-water is relatively low. With the exception of one specimen of Neaphaenops, all anophthalmid beetles collected were found to be restricted to wet situations,—on the banks of cave streams and pools, beside or under a roof drip, etc. But this habit of extreme gregariousness, as Mr. H. S. Barber suggests, may simply reflect the unusual

dryness of the past season. By far the greater number of specimens were taken on or under wet wood which had lain undisturbed for a long time and had become thoroughly rotten, a thick deposit on the wood of a black mud, evidently discharged by worms, being the best indication of the presence of the insects. Several caves were visited which were apparently devoid of anophthalmids everywhere except between wet rotting boards, and there the insects were plentiful.

A single specimen of *Anillinus fortis*? (Barber deter.), a minute fossorial bembidiinid, was taken in association with *Neaphaenops* and *Pseudanophthalmus* in wet wood in Crystal Cave, Monteagle, Tenn.

The method of trapping described by Mr. Barber in the companion paper of this issue was used with great success in several cases. Galt's solution proved to be a splendid preservative and apparently non-repellent. A saturate aqueous (3/4) and glycerine (1/4) solution of picric acid gave good results. It was found, however, that a little of the acid on the cricket-screen would prevent the entrance of the beetles. (Traps loaded with picric acid had best be filled with the preservative before the screens are placed over them.) It is hoped that the picric acid will act as an adequate histological fixative so that a study of the sense organs of anophthalmids may be made from material preserved in this fluid.

It is with great pleasure that the writer expresses his keen appreciation of the important part which Mr. H. S. Barber of the U. S. National Museum has played in instigating and encouraging this work. Also, for the splendid coöperation which the writer received from the following helpers, he wishes to announce his sincere gratitude: Mr. H. P. Löding of Mobile, Ala., Dr. Walter B. Jones, Director of the Alabama Museum of Natural History, Mr. Carl T. Jones of Huntsville, Ala., Mr. R. M. Harper of the Florida State Geological Survey, Mr. O. D. Higginbotham of Frankford, West Va., and Mr. J. J. Raulston, Manager of Wonder Cave, Monteagle, Tenn.

METHODS

The types described in this paper were killed and preserved in carbon tetrachloride, then dried. They were magnified 14× and projected flat by optically bending the insect at points of articulation only. The drawings have been since reduced about one fifth. Measurements were taken of the insects straightened in a similar manner, and refer to the distance from the elytral apex to the further mandible apex when the jaws are closed.

The full length illustrations alone are drawn to the same scale. An attempt has been made to indicate on the left elytron the striae and on the right elytron the pubescence and gross sculpturing, such as the humeral depressions. The drawings of the copulatory organs are of the extended portions only.

Gen. **NEAPHAENOPS** Jeannel

Neaphaenops Jeannel, 1920, Bull. Soc. ent. Fr., p. 154.—1931, Archiv. de Zoöl. exper.

Some of the characters of this genus as given by Jeannel must necessarily be broadened to accommodate the form herein described and some must be limited to *N. tellkampfi* Erichson, the hitherto sole representative of the group. The more important generic attributes as contrasted with *Pseudanophthalmus* now seem to be these:

Size relatively large (abt. 7 mm.). Smooth, shining. Head, thorax elongate. Elytra oval, strongly convex, glabrous; humeral region sloping, its marginal setigerous papillae closely grouped and widely separated from the medial set. Appendages exceptionally long; femora hairy on outer surface throughout length and densely so near distal end. The group is apparently an aberrant specialization.

Neaphaenops is characteristically found not under close cover but in larger crevices and in the open where it occurs as a cursorial type. It is frequently observed running over the floor of relatively dry chambers.

Neaphaenops intermedius Valentine, sp. nov.

Fig. 1. Length 5–6 mm. Brown with reddish tone, shining. Head relatively wider than in *tellkampfi* and not so elongate; subterminal joint of maxillary palpi not longer than terminal; central marginal lobe of labrum distinct, edged with back. Frontal grooves continuous with deep depressions limiting eye-areas. Pronotum relatively shorter and broader, its hind angles, of which there are two sets, are sharp (outer acute, inner or secondary obtuse), the outer being less elevated than in *tellkampfi*. Elytral striae shallow, punctures less distinct than in *tellkampfi*. Recurved apical stria distinct, crescentic, joined to 3rd stria by shallow punctate depression.

Wonder Cave, Monteagle, Tenn.: 2 males March 17, 1931. One of these was found running over the floor of a rather dry stalactitic passageway above the water level. Crystal Cave, Monteagle, Tenn.: 1 pair March 17, 1931. Measures slightly smaller (5.7 mm. and 5 mm.), though otherwise similar. These caves are thought to be connected.

Type: Wonder Cave (coll. Valentine).

Gen. **PSEUDANOPHTHALMUS** Jeannel

Pseudanophthalmus Jeannel, 1920, Bull. Soc. ent. Fr., p. 154.—1931, Archiv. de Zoöl. exp.

Averaging smaller than *Neaphaenops* (about 4 mm.). Less convex. Head, pronotum and appendages much less attenuated, approaching a typical, relatively primitive condition. Humeral angles more prominent. Elytra pubescent.

Group Menetriesi

Medium to large size (4–6 mm.). Relatively convex. Elytral striae well indicated. Reflexed humeral elytral margin elevated, serrate and setigerous.

Pseudanophthalmus robustus Valentine, sp. nov.

Fig. 2. Nearest to *menetriesi*. Length 4–5 mm. Darkish brown with a faint reddish tone, shining. Head broad. Pronotum slightly broader than long, finely and sparsely pubescent; margins not deeply sinuate behind; basal depressions deep, foveate; hind angles sharp, obtuse; basal contour bulges posteriorly. Elytra well rounded laterally; marginal keel with its humeral serrations conspicuous, terminating anteriorly in a short forward pointing spur; striae deep, foveate; intervals each with a row of short very fine hairs; recurved apical stria strong; enters 2nd and 3rd striae near 3rd discal papilla; 1st discal papilla on level with 4th marginal papilla. Legs relatively short.

Johnson's Cave, Monterey, Tenn.: many taken March 18, 1931.

Type: Johnson's Cave (coll. Valentine).

Group Pusio

Medium to small (less than 4.5 mm.), flattened species. 2nd joint of antenna not shorter than a fifth less than 3rd; terminal 3 slightly wider than preceding. Elytral striae poorly indicated. Apical groove (recurved elytral stria) short, crescentic, ending abruptly anteriorly, but usually connected with the 3rd stria.

Pseudanophthalmus pusio var. **punctatus** Valentine, subsp. nov.

Fig. 3. Length 3.1 mm. Yellowish brown. Head roundish, densely and rather conspicuously punctate; labrum without central lobe, margin rather deeply excavated; 2nd and 3rd joint of antenna subequal in length. Pronotum sparsely pubescent; margins arcuate from distal seta to base of angle; hind angles about 90°; basal contour almost transverse; mid discal line impressed to form a wide groove. Elytra densely

pubescent and finely punctate; about as depressed as *hubbardi*; humeral angles well rounded, slope of shoulders inconsiderable; striae indicated best in the apical third of the elytra; intervals convex; apical groove distinct and, after interruption at apex, continued medially to 1st stria to join its mate from the other elytra forming a common groove; elytra not separated at apex but joined, apparently by a small triangular piece. Copulatory organ not wider near apex; apex spatulate.

One male taken in Tommie's Cave, Newport, Va.

Type: Tommie's Cave (coll. Valentine).

Pseudanophthalmus higginbothami Valentine sp. nov.

Fig. 4. Length 3.6–4 mm. Dark straw yellow. Head more elongate than *pusio*. Labral margin less concave. 2nd and 3rd antennal joints subequal. Pronotum sparsely pubescent; margins evenly sinuous over proximal two thirds; hind angles acute and well elevated; basal contour concave. Elytra finely pubescent, decidedly flattened above; striae very poorly expressed, only the first 3 being evident; basal border feebly sloping; humeri distinct, their bristles and those of the lateral margins conspicuous; sutural line impressed to form a groove; apical groove abruptly curved, very wide; elytra separate at apex. Copulatory organ wider near apex; apex wedge-shaped.

Large series collected in 3 caves within the radius of a mile at Frankford, W. Va., Feb., March, 1931. The insect is named after Mr. O. D. Higginbotham whose excellent trapping technique enabled the author to take the first specimens of this species and in whose caves many other unique specimens were taken.

A specimen which the writer has not seen in the Leconte collection in the Mus. of Comp. Zool. labelled "Pusio, W. Va." may be similar to this.

Type: Higginbotham's large cave (coll. Valentine).

GROUP ENGELHARDTI

Medium to small (less than 4.5 mm.). Resemble *group pusio* in the tendency for the terminal 3 antennal joints to be enlarged; differ from this group in the 2nd antennal joint which is about one fourth shorter than 3rd, in the more marked development of the elytral striae which are punctate, and in the apical groove which is longer and straight or bisinuate, not crescentic, and often merges into the 3rd stria without interruption. The legs and mandibles are usually relatively longer in this group.

Pseudanophthalmus hirsutus Valentine, sp. nov.

Fig. 5. Close to *engelhardti*. Length 3.8–4.5 mm. Yellowish brown. Decidedly depressed. Head rounded; labrum with median marginal tooth; 2nd joint of antenna one fourth shorter than 3rd, 4th about one seventh shorter than 5th. Pronotum elongate; margins feebly arched from distal seta to base of hind angles; hind angles obtuse, not sharp, outer side with slight convexity; basal contour concave; basal depressions foveate, punctate; disk with 3 to 5 longish bristles in a row on either side of the mid line occupying about a third of the disk length. Elytra elongate, flattened, with nearly parallel sides; basal contour feebly sloping; basal depression poorly indicated; humeri rounded, conspicuously setigerous; striae well defined, shallowly punctate; apical groove reaching about one fifth of the elytral length, bisinuate, entering the 3rd stria after making a sudden bend. Legs rather long.

This form, which resembles *engelhardti*, may later be given subspecific rank.

A large series taken from King Solomon's Cave, Cumberland Gap, Tenn., March 19, 1931.

Type: Kig Solomon's Cave (coll. Valentine).

Pseudanophthalmus hirsutus, mutant?

Fig. 6. Resembles *hirsutus*. Length 3.5. Head relatively narrower and longer; 4th joint of antenna one fourth shorter than 5th. Pronotum more elongate; only 2 pairs of discal setae present. Elytra narrower, more sparsely pubescent; shoulders more sloping; apical groove finer. Legs a little longer.

A single male taken in association with *hirsutus*. Since this is merely an exaggerated form of *hirsutus* living with the latter, it is doubtful that it is more than a temporary variant.

Pseudanophthalmus lödingi Valentine sp. nov.

Fig. 7. Length 3.9–4.2 mm. Yellowish brown. More convex than *hirsutus*. Head rounded, distinctly punctate medially; mandibles short; labrum with central marginal lobe poorly defined; 2nd joint of antenna one fourth shorter than 3rd. Pronotum very sparsely pubescent; margins gently arcuate from distal seta to base of hind angle or sinuate to agle apex; hind angles approximately 90°; base slightly concave within distinct, obtuse secondary angles. Elytra not flattened, finely and sparsely pubescent; striae well marked, punctate; apical

groove prominent, narrow, bisinuate, reaching one fifth of elytral length, entering 3rd stria after an abrupt turn; elytral apices rounded, separate.

The first examples of this species were collected by Mr. H. P. Löding after whom it is a pleasure to name it. 2 specimens were taken June 21, 1930, in Shelta Cave, Huntsville, Ala. 8 additional specimens were taken by the writer March 14, 1931.

Type: Shelta Cave (coll. Valentine).

Pseudanophthalmus humeralis Valentine sp. nov.

Fig. 8. Resembles *hirsutus*. Length 3.9–4.5 mm. Reddish brown. Elongate, more convex than *hirsutus* or *gracilis*. Head rather long, finely punctate above; labrum with central lobe indistinct; 2nd joint of antenna about one fourth shorter than 3rd. Pronotum feebly pubescent, a pair of setae in transverse row on either side of mid line on disk; reflexed apical portion wide, punctate; margins from distal seta gently sinuate to tip of hind angles or arcuate to angle base; basal angles sharp, obtuse; secondary angles small, distinct; basal contour transverse, feebly bisinuate; basal impressions deep, rather roughly sculptured. Elytra elongate, disk a little flattened, sparsely pubescent; humeral depressions well defined; humeri very prominent, rounded; reflexed margins wide, forming on humeri a conspicuous keel which is feebly crenulate; striae punctate, well expressed medially; apical groove long, nearly straight, occupying more than apical fifth of elytral length.

Monteagle, Tenn. March 17, 1931: Wonder Cave—2 males; Crystal Cave—2 females and 1 male.

Type: Crystal Cave (coll. Valentine).

Pseudanophthalmus gracilis Valentine sp. nov.

Fig. 9. Length 4.2 mm. Yellowish brown. Elongate, decidedly depressed. Head elongate, rather large, very finely punctate; labrum with no trace of medial tooth; 2nd joint of antenna about one fourth shorter than 3rd. Pronotum very finely and sparsely pubescent; margins strongly sinuate to apex of basal angles which are produced and acute; secondary angles very small; basal contour transverse. Elytra elongate, tapering apically, flattened; very finely but rather densely pubescent; basal depression round and small; humeral angles distinct, shoulders sloping; no seta-cluster on humeral margin; striae poorly impressed, not punctate, intervals convex; apical groove short, only reaching one sixth the elytral length.

Tommie's Cave, Newport, Va.; 2 females and 1 male taken March 23, 1931.

Type: Tommie's Cave (coll. Valentine).

The four species listed above under the group *engelhardti* may very possibly suffer reduction to subspecific rank under light shed by additional specimens from new localities.

GROUP GRANDIS

Medium to large species (over 4.5 mm.). Head relatively large. Labral margin concave. Antennae long, slender, no appreciable tendency to thicken distally, joint 2 less than three fourths the length of joint 3. Elytral striae feebly impressed, apical stria short, crescentic, not entering the 3rd stria directly if at all. Legs long.

Pseudanophthalmus grandis Valentine sp. nov.

Fig. 10. Length 5.2–6.8 mm. Yellow brown with often a tinge of red. Convex. Head large, rather elongate; labral margin crenulate; lateral clypeal depressions wide; antennae very long and slender; 2nd joint nearly one third shorter than 3rd. Pronotum elongate; few longish hairs on disk; margins evenly sinuate to tip of hind angle; hind angles produced, acute; secondary angles very obtuse; basal contour nearly transverse; basal depressions simple, these and lateral margins punctate. Elytra finely, densely pubescent; basal depression small, shallow; humeri distinct, shoulders very sloping; humeral group of papillae compact and widely separated from medial group; striae well indicated medially, punctate; apical groove short, crescentic, open, entering 3rd stria near 3rd discal seta. Legs very long.

Large series taken by trapping in Higginbotham's 3 caves and Kaufman's Cave (1 mile distant), Frankford, W. Va., Aug. 1930, Feb. and March 1931.

This fine species resembles *Neaphaenops* in general appearance. It is the largest of the genus so far recorded.

Type: Higginbotham's large cave (coll. Valentine).

Pseudanophthalmus fuscus Valentine sp. nov.

Fig. 11. Length 4.6–5.6 mm. Dark yellowish brown to fuscous brown, shining. Elongate, more depressed. Head large, round; labral margin papillate; lateral clypeal depressions poorly indicated; antenna long, slender, 2nd joint one third shorter than 3rd. Pronotum with few scattered hairs on basal half; strongly produced antero-later-

ally; apical margin strongly reflexed into semilunar collar; margins nearly straight and very sloping; hind angles acute, elevated and generally much produced behind; basal secondary angles very obtuse, small; basal contour feebly bisinuate, transverse; basal depressions transverse, nearly smooth; mid line depressed to form a groove. Elytra convex; densely and rather heavily pubescent; basal depressions very small, shallow; humeri rounded, shoulders rather transverse; elytral margins reflexed strongly, gently and evenly arcuate but nearly parallel; striae as in *grandis;* apical groove almost circular, meeting 3rd and 2nd striae, 2nd joint of front tarsus of male bearing delicate spine.

Large series taken by trapping in Higginbotham's two large caves and in Kaufman's Cave, Frankford, W. Va., Feb. and March, 1931. This form can usually be separated by color alone.

Type: Kaufman's Cave (coll. Valentine).

Pseudanophthalmus subaequalis Valentine sp. nov.

Fig. 12. Resembles *fuscus.* Length 4.4–5.4 mm. Yellowish brown. Rectangular, slightly convex. Head very round, large; labral margins finely papillate; clypeal depressions mere grooves; 2nd joint of antenna little less than one third shorter than 3rd. Pronotum not as produced at anterior angles; basal angles not as produced; basal contour with very flat secondary angles or transverse; basal depression transverse, punctate. Elytra more parallel; basal depressions larger, deeper; striae ill-defined, represented marginally only by their punctures; apical groove very short, reaching little above 3rd discal seta, and straight.

Large series taken in Higginbotham's 2 larger caves and in Kaufman's Cave, Frankford, W. Va., Feb., March, 1931.

Type: Kaufman's Cave (coll. Valentine).

These three species of the group *grandis* are clearly separate.

LIST OF NORTH AMERICAN ANOPHTHALMIDS[1]

Genus Neaphaenops: a small group of highly specialized forms; taken from central Ky. and southern Tenn.

1. *N. tellkampfi* (Er.)
2. *N. intermedius* n. sp. (Valentine)

Genus Pseudanophthalmus: a very large genus apparently limited to the southern Appalachian limestone system and not extending further north or west than the southernmost boundary of glaciation.

Group Menetriesi: a presumably rather large group of limited

[1] See map, H. S. Barber, Traps for Cave-inhabiting insects, in this issue.

range found principally in the Mammoth Cave district but also in northern central Tenn.

3. *P. menetriesi* (Mots.)
4. *P. striatus* (Horn)
5. *P. pubescens* (Horn)
6. *P. audax* (Horn)
7. *P. robustus* n. sp. (Valentine)[2]

Group Pusio: a presumably large group from the Shenandoah Valley, Va., southwestern W. Va. and perhaps also eastern Ky.

8. *P. pusio* (Horn)
   a. var. *punctatus* n. subsp. (Valentine)
9. *P. hubbardi* (Barber)
   a. var. *limicola* (Jeannel)
   b. var. *parvicollis* (Jeannel)
10. *P. higginbothami* n. sp. (Valentine)[2]
11. *P. pusio* (Packard), a lost sp.

Group Engelhardti: a large and widely distributed group extending from southern Va. south to northern Ala.

12. *P. engelhardti* (Barber)
13. *P. hirsutus* n. sp. (Valentine)[2]
14. *P. lödingi* n. sp. (Valentine)[2]
15. *P. humeralis* n. sp. (Valentine)[2]
16. *P. gracilis* n. sp. (Valentine)[2]

Group Grandis: apparently a small circumscribed fauna of southwestern W. Va.

17. *P. grandis* n. sp. (Valentine)[2]
18. *P. fuscus* n. sp. (Valentine)[2]
19. *P. subaequalis* n. sp. (Valentine)[2]

Group Horni: specialized, comprising one species of rock-crevice type from central Ky.

20. *P. horni* (Garman)

Group Eremita: a closely related group from northern Ky. and southern Ind.

21. *P. eremita* (Horn)
   a. var. *morrisoni* (Jeannel)
   b. var. *stricticollis* (Jeannel)
22. *P. barberi* (Jeannel) = *P. eremita* var. *barberi* (Jeannel)

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CHAPEL HILL, N. C.

[2] Paratypes deposited in the U. S. National Museum.

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EXPLANATION OF PLATES 20–22

PLATE 20

Fig. 1. *Neaphaenops intermedius* n. sp. Valentine. Male. Details of apical groove, antenna cleaner and front tarsus.

Fig. 2. *Pseudanophthalmus robustus* n. sp. Valentine. Female. Details of apical groove and antenna cleaner; front tarsus and copulatory organ of male.

Fig. 3. *Pseudanophthalmus pusio* var. *puctatus* n. subsp. Valentine. Female. Details of apical groove and antenna cleaner; front tarsus and copulatory organ of male.

Fig. 4. *Pseudanophthalmus higginbothami* n. sp. Valentine. Female. Details of apical groove and antenna cleaner; tarsus and copulatory organ of male.

PLATE 21

Fig. 5. *Pseudanophthalmus hirsutus* n. sp. Valentine. Female. Details of apical groove and antenna cleaner; front tarsus and copulatory organ of male.

Fig. 6. *Pseudanophthalmus hirsutus* n. sp. Valentine. Male, mutant? Details of apical groove, front tibia and tarsus.

Fig. 7. *Pseudanophthalmus lōdingi* n. sp. Valentine. Female. Details of apical groove and antenna cleaner; front tarsus and copulatory organ of male.

Fig. 8. *Pseudanophthalmus humeralis* n. sp. Valentine. Female. Details of apical groove and antenna cleaner; front tarsus of male.

PLATE 22

Fig. 9. *Pseudanophthalmus gracilis* n. sp. Valentine. Female. Detail of apical groove and antenna cleaner; front tarsus and copulatory organ of male.

Fig. 10. *Pseudanophthalmus grandis* n. sp. Valentins. Male. Detail of apical groove, antenna cleaner, front tarsus and copulatory organ.

Fig. 11. *Pseudanophthalmus fuscus* n. sp. Valentine. Female. Detail of apical groove, and antenna cleaner; a less typical thorax and front tarsus of male.

Fig. 12. *Pseudanophthalmus subaequalis* n. sp. Valentine. Female. Detail of apical groove, antenna cleaner; front tarsus of male.

PLATE 20

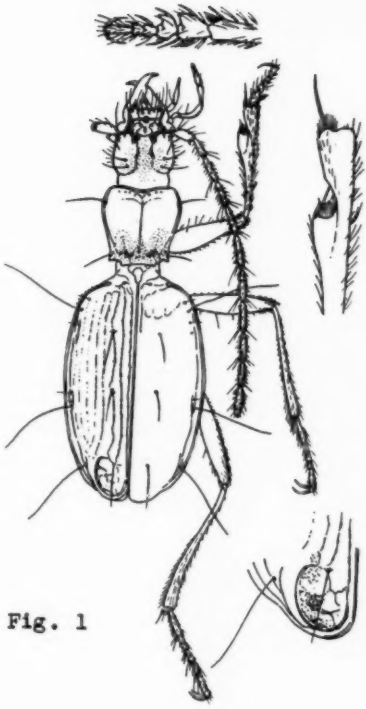

Fig. 1

Fig. 2

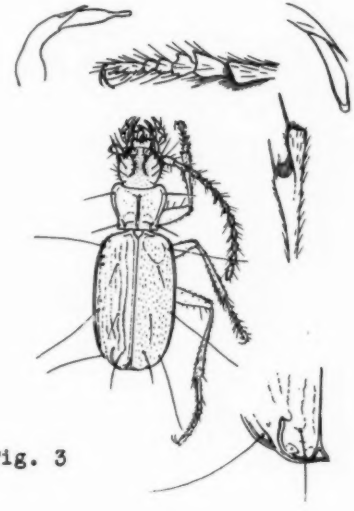

Fig. 3

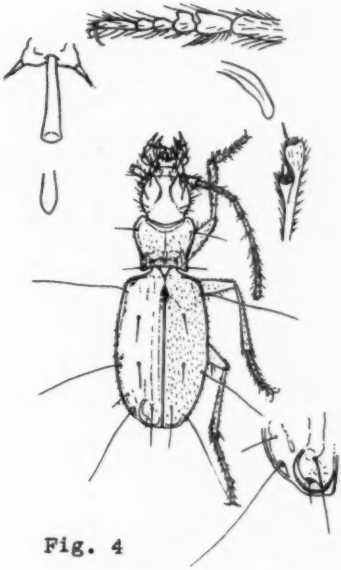

Fig. 4

PLATE 21

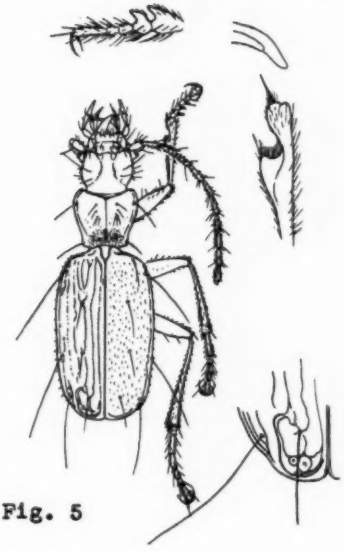

Fig. 5

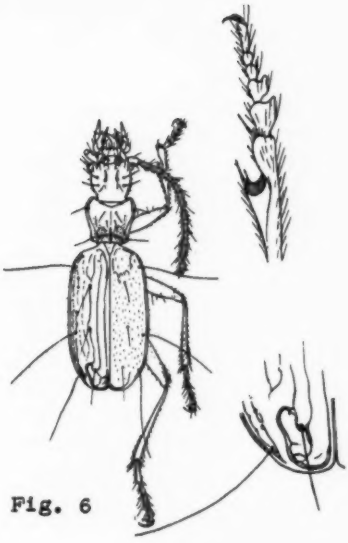

Fig. 6

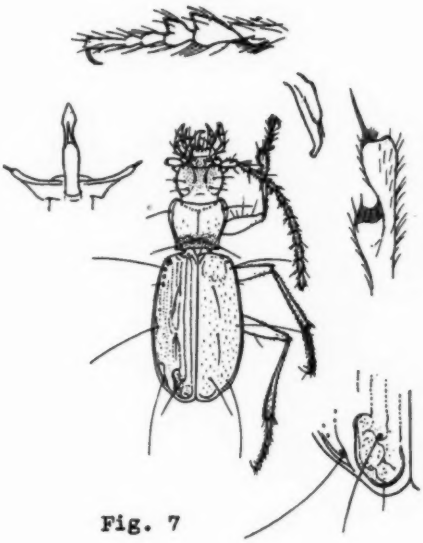

Fig. 7

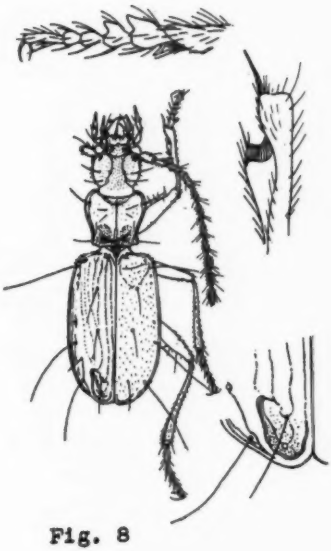

Fig. 8

PLATE 22

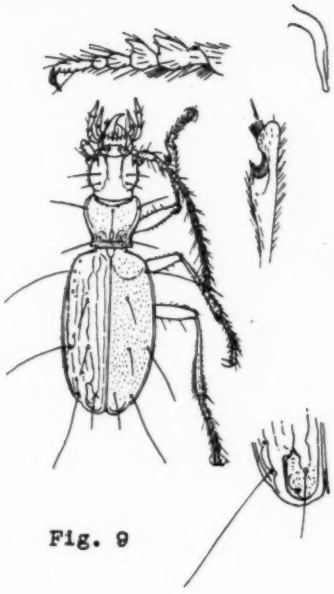

Fig. 9

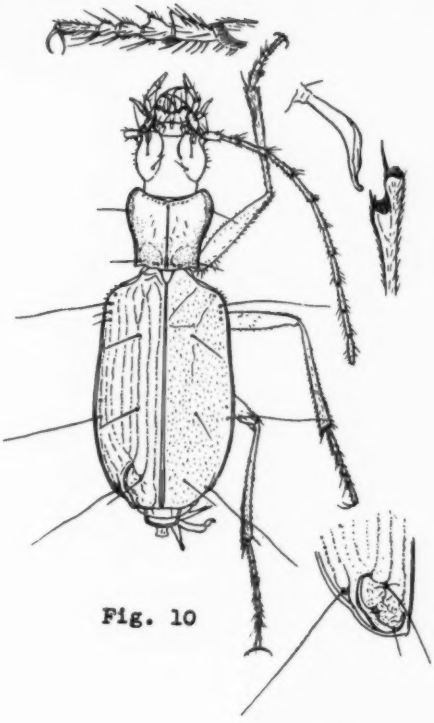

Fig. 10

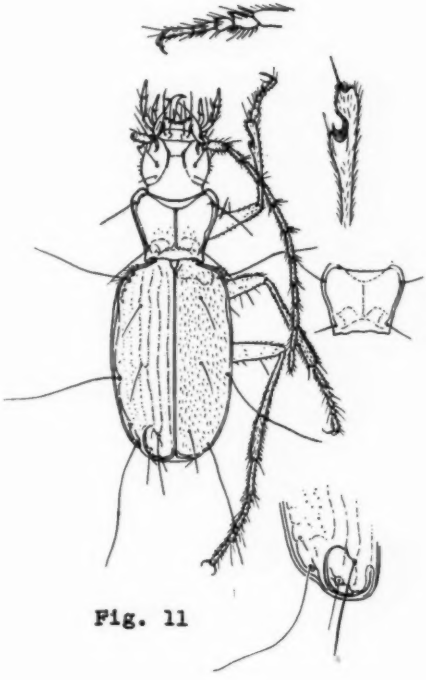

Fig. 11

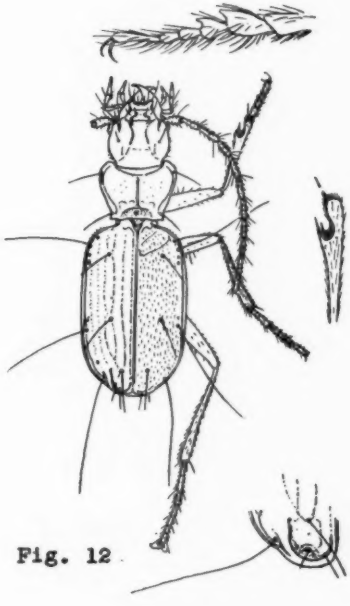

Fig. 12

TRAPS FOR CAVE-INHABITING INSECTS

By H. S. Barber

Plate 23 and 1 Text Figure

Being a perennial population, no species should be known to collectors and to students by single samples but rather by a series selected to show its variation in the colony represented. With perhaps few exceptions supposed "rarity" of a species indicates only ignorance of its habits or inaccessibility of its habitat. Ways of obtaining the "rare" forms can usually be found if the place, time and behavior are known.

The discussion following may, it is hoped, contribute to our long neglected advance in understanding the local survival of the non-migratory and highly specialized subterranean forms which became established in their present habitats long before the first (Nebraskan) of the five or six Pleistocene glacial stages, and of which no representative is expected to be found to inhabit caves in glaciated territory nor probably below the preglacial marine shoreline which, according to Cooke 1930 (Journ. Wash. Acad. Sci., vol. 20, p. 391), extends from Texas to beyond New Jersey at a level about 265 feet above present sea level.

The primary interest in American Anophthalmids being zoogeographic, and the object of these notes being to induce evidence on the little known or the perhaps numerous unknown species, a map is here introduced (Plate 23) upon which the chief known localities for the twenty-two supposedly distinct species so far discovered in our fauna are indicated as listed, and the approximate extent of the several ice sheets is shown by shading. Caves in the glaciated regions probably harbor species of insects which are capable of migration, but unless there are crevice or subsoil drainage connections with inhabited caves that were not covered by glacial ice, it is not likely that such specialized cave-beetles as the Anophthalmids reside there. Verbal information that supposed Anophthalmid fragments had been found in a cave in southwestern Wisconsin may be erroneous but calls attention to the large unglaciated area in that region in which preglacial cavernicoles might have lived and may yet be found.

Our usual concept of a cave being derived from the orifice and passages by which we can enter, few seem to grasp the intricate and vast extent of the subterranean drainage system in limestone deposits and the probability that, in the long period since they could survive above ground, these beetles have had ample time to explore the limits of these crevices and passages in each of the underground systems in which they are at home. The new Anophthalmid described by Garman 1892 (Science, xx. p. 241) occurred in small crevices exposed in limestone quarries at Lexington, Ky. These crevices are probably part of the subsoil drainage which he discusses, but being too small for human entry are not thought of as "caves." Thousands of caves are known locally but not marked upon maps, and some way of recording their location and the positive or negative results of their investigation for cave insects should be started. The many active students of this subject in Europe contrast strongly with the lack of interest or understanding here, and the superb monographs of *Trechinæ* (including the Anophthalmids) and *Bathyscinæ* by Dr. Jeannel of the Paris Vivarium contrast equally with our scanty publications on this subject.

Allusion has been made (Journ. Wash. Acad. Sci., vol. 19, p. 49) to the great contrast between the few *Anophthalmus* seen by a collector in a cave and the much larger number which may be found in traps exposed there. Results of rather harsh tests of some experimental traps may suggest research to some one with leisure and opportunity not within the reach of the writer.

In the statement above cited, about 20 visits to caves had resulted in only 7 of these beetles being seen under natural conditions in contrast to about 100 specimens taken from two examinations of a few traps in four of the caves. Several subsequent visits to these caves have not increased the number seen outside of the traps but those found in them now total more than 600 individuals, most of them from a single small cave. Of this number nearly three-fourths were destroyed, having died and been dismembered by the maggots which under normal conditions are supposed to be their food; but in some of the traps, below discussed, all beetles which had been caught during a period of several months of inattention made good cabinet specimens. If examination could be made frequently enough, such loss of specimens would be much less, but the writer could not often spare the time for the long trip with its tiresome search, so traps designed to preserve the catch were used as below described.

The desire to capture enough specimens from the Luray colony

(*Pseudanophthalmus hubbardi* Barber 1928) to determine variability and possible identity with the Erhart Cave species (*pusio* Horn 1868) led to the trial of baited[1] glass vials set in wet mud or other favorable positions in the caves. Later, through the very courteous privileges extended by the management of the Luray Caverns, improved traps supplied enough topotypes of *hubbardi* (previously known from only one specimen found 45 years earlier) to adequately represent the colony.

Traps used were of several sizes but the spots chosen for their emplacement appeared to have more effect upon the catch than their dimensions. Of a score of traps placed in a crooked 50-foot line in one cave, certain small glass cylinders, 20 mm. in diameter by 40 mm. high, often contained the remains of 20 to 35 *Anophthalmus* while near-by traps of the same or of much larger size might have caught none. The size most used was a cylinder 1 by 4 inches. A metal tube of the same diameter as the glass, but several inches longer and supplied with a longer wooden plunger, was used to cut and remove the mud so that the glass cylinder could be set with its open mouth level with the surface. Several having been broken in the attempt to set them where the rock beneath the mud was too near the surface, probing with a stiff wire to find deeper locations was adopted, and shorter cylinders were found to be much more convenient.

The markers by which it was hoped to recognize the position of the traps after the lapse of some weeks or months were often disturbed or displaced by other visitors or by small mammals, paper being carried about and torn to bits, presumably by rodents or shews, the latter sometimes being found in a trap. The mud cores pushed out of the metal tubes used in cutting the holes were found to be very satisfactory markers if set upon a stone placed over the trap, but raised a few millimeters from the mud surface. When desirable to place a trap on wet

[1] Since dipterous larvae and perhaps adults are supposed to be the chief food of Anophthalmids, it is probable that a bat or mouse dying in the cave would attract not only the numerous kinds of flies there present, but the predators as well. To obtain an immediately effective bait for traps to be examined within a day or two, Dr. Rambousek advised preparation, two weeks before use, of a wet mixture of ground, raw meat and a soft cheese in a glass jar covered tightly with cloth to exclude flies and kept warm enough to permit putrefaction. Irrespective of the collector's personal taste, this odorous bait is very attractive to most cave-insects and served admirably, he said, to entrap Anophthalmids as well as Silphids, in small dishes (he used several nested sizes of thin glass beakers) containing a little bait covered with paper strips and placed in the mud floor or in piles of small stones so that the beetles could easily crawl into the pitfalls.

rock surfaces where no mud was available, it was surrounded and covered by piled-up stones, care being taken that the beetles could easily reach the edge of the glass; but the trap appears more effective if the bait odor escapes through the narrow crevice between the mud surface and a slightly raised covering stone which also serves to drain off drip from the roof, as well as to discourage small mammals.

The writer's experience has been confined to regions wherein the large cave crickets (*Ceuthophilus stygius*) were not in evidence and all insect visitors to the bait were so small that a quarter-inch space between the inner and outer vials of the trap was a sufficient barrier and pitfall. But if *Ceuthophilus* are present, some protection against them is probably necessary or the bait may be consumed, the trap clogged with their bodies, or even the feebler insects attracted to the bait may be devoured. Wire screening of quarter-inch mesh, cut into 3-inch squares, has been used by the writer to exclude small mammals and should also be effective against the crickets unless their expected predatory habits and congregation about the attractant should otherwise interfere with the catch. The corners of the screen are merly bent down and pressed into the mud to secure it over the trap.

A stable, non-repellent preservative for the captured samples is a great desideratum. Ethylene glycol, or its liberal mixture with Galt's preservative,[2] or the latter mixed with glycerin, yielded fairly good specimens from traps neglected for nearly six months (Oct. 21, 1928, to Apr. 6, 1929), the beetles being, usually, well extended with extruded genitalia, and, after having been washed in water, dehydrated in alcohol, cleared in xylol and dried, keeping their shape although showing some shrinkage of the viscera away from the integument. As fluid-preserved samples of flies the vast numbers of Phorids, Borborids,Mycetophilids, etc., appeared in good shape for study (*Sciara lurayi*, Johansen 1929—Proc. Ent. Soc. Wash., vol. 31, p. 88, having been described from such samples), and when carefully dehydrated and dried out of xylol, they yielded rather remarkable samples.

The claims advanced for the recently introduced proprietary antiseptic, "Hexylresorcinol solution, surface tension .37," led to its trial with surprisingly good results, after a six weeks' exposure. A subsequent longer exposure was less fortunate, owing perhaps, to excessive dilution of the preservative by the mass of dead insects.

[2] Galt's solution is composed of 5 parts of common salt, 1 part of saltpeter, and 1 part of chloral hydrate in 100 parts of water.

The sterilizing qualities of copper led to the trial of one trap containing blue vitriol solution and a little glycerine placed in Crystal Cave near Boonsboro, Maryland. When recovered after about seven months, very good specimens of a Silphid, supposed to be *Catops alsiosus* (Blatchley 1910—not Horn 1885)[3] were found, together with several of its larvae, these latter not having been found in other traps, and although somewhat contracted and green from the fluid, they swelled and lost most of their unnatural color when washed in water and brought up through successive strengths of alcohol. This cave has also yielded several specimens of *Quedius spelaeus* Horn as well as of the less conspicuous Aleocharid, *Emplenota lucifuga* Casey (Chapin determ.), both of which were hitherto known only from west of the Alleghenies.

Zenker's fluid having been recommended as well as the addition of corrosive sublimate to the Hexylresorcinol solution, a change of traps was made but revisit was too long delayed and higher water flooded most of the traps. After nine months (May 18, 1929, to Feb. 22, 1930) some undisturbed traps were recovered and examined with very interesting but mostly unsatisfactory results. Most of those intact had contained Zenker's fluid from which the acetic acid had been omitted, it having been feared that it would act as a repellent, and ethylene-glycol added lest the fluid evaporate. Whether or not either or these changes induced the trouble is not known, but on all of the very many specimens in the solution the surface and especially the long setae were coated with a brownish, crystalline, nearly insoluble deposit which turned black on exposure to ammonia, potassium hydroxide, or cyanide solution, but which dissolved (accompanied by disarticulation of the insect) in strong hydrochloric acid. Other reagents also failed to remove the incrustation. No decay was observed in the multitude of insects in the fluid, and if a method of cleaning were found, Zenker's fluid might be satisfactory.

Accidents to most of the check-traps had occurred but one contained well preserved flies, rove beetles and larvae, and in another cave two trap vials contained more than 50 perfect Anophthalmids with a few of their larvae, besides hundreds of flies (about 6 species), Silphids and rove beetles, all in fine condition, even the parasitic fungi (*Laboulbenia subterranea* on the Anophthalmids and a new *Stigmatomyces* on the Helomyzid fly *Oecothea fenestralis*) being in satisfactory condition

[3] Dr. Hatch corroborates this identity but adopts the name *C. eratiosus* Blanchard for the species.

according to Dr. Thaxter. Muddy hands had unfortunately discouraged the labeling of these two traps, and memory was uncertain, but the presence of potassium in one indicated that the preservative was Galt's solution while the other is believed to have been filled with a larger quantity of Hexylresorcinol than had been used in other traps in which this fluid had failed to preserve the catch.

For effective sampling of the insect inhabitants of caves in a particular region, a standard trap should be available in sufficient numbers to

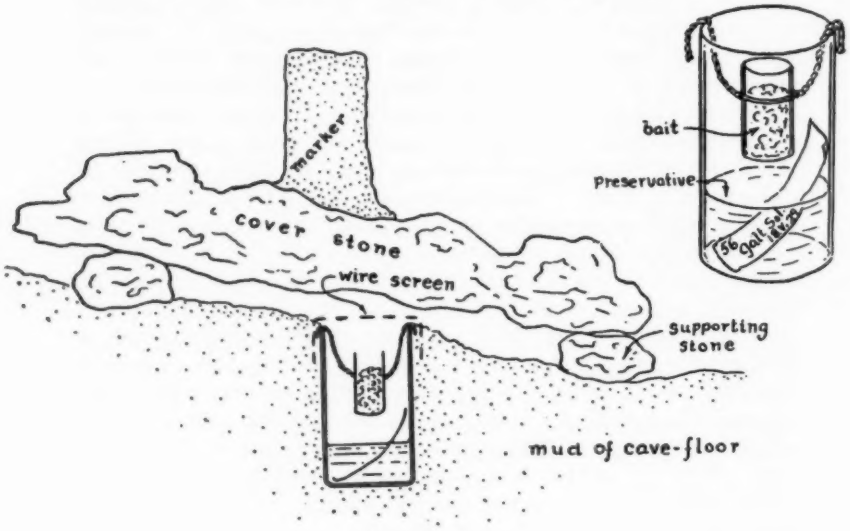

FIG. 1

permit rapid setting and replacement under the cramped and muddy conditions one encounters in underground passages. An open wooden box about 5 inches high, 8 inches wide and 12 inches long, surrounded lengthwise by a strap by which it can be carried or moved with one hand without being upset, should contain the emergency candle and matches (for use if the carbide light or electric torch fails), the bottle or bottles of preservative, equipped with pipette and rubber bulb, the prepared traps, the probing wire, the metal tube for cutting holes in mud with its

plunger for pushing out the mud cylinder, label strips if the traps are to be numbered or preservative recorded, and notebook if record is to be made of position, number, preservative, or peculiar condition. The notebook and a plan of numbering each trap are essential if the investigator intends to periodically visit several caves on a planned route.

The trap consists of a cylindrical glass vial about 1 by 3 inches, with a smaller vial filled with putrid meat fastened a little below the top (but so that the cave-beetles cannot crawl to the bait) by cork wedges or spring wire. This bait bottle should be one-half or one-third the diameter of the outer cylinder, and less than half as long. When the place for a trap is selected the wire probe indicates if the mud layer is deep enough, the metal tube is pushed down to the required depth, twisted and withdrawn filled with mud, the glass trap is inserted into the hole and the mud rubbed smooth to the top of the glass, the preservative injected between the bait vial and the outer trap vial, a linen ledger, soft pencil label prepared and dropped into the preservative, appropriate record made in memorandum book, a convenient flat stone resting on some thin support so as to leave a crevice not over 5 mm. high is placed over the trap and upon it is placed as a marker the mud core pushed with the plunger out of the metal tube. When revisited a month or so later, the marker is located, the bait vial removed, a cork inserted into the trap vial which is then removed by twisting, a new trap place in the hole with proper preservative charge, label and memorandum and the stone and marker replaced. Examination of the contents of each trap is best made in the laboratory, but can be done in the field if necessary. Accompanying sketches may better show the traps and the manner of placing them (Fig. 1). A perfect non-repellent preservative fluid is a great desideratum and suggestions are earnestly solicited.

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PLATE 23

EXPLANATION OF MAP[4]

1. *Neaphaenops tellkampfi* (Er. 1844)—common.....Mammoth Cave, Ky.
2. *Naephaenops intermedius* n. sp. Valentine 1931—only 4 known Monteagle, Tenn.
3. *Pseudanophthalmus menetriesi* (Mots. 1862)—common...Mammoth Cave, Ky.
4. *Pseudanophthalmus striatus* (Mots. 1862)—not common.Mammoth Cave, Ky.
5. *Pseudanophthalmus pubescens* (Horn 1868)—common.....Cave City, Ky.
6. *Pseudanophthalmus pusio* (Horn 1868)—very few known..Erhart's Cave, Va.
7. *Pseudanophthalmus eremita* (Horn 1871)—common....Wyandotte Cave, Ind.
8. *Pseudanophthalmus audax* (Horn 1883)—very few known.Ronald's Cave, Ky.
9. *Pseudanophthalmus horni* (Garman 1892)—common.....Lexington, Ky.
10. *Pseudanophthalmus hubbardi* Barber 1928—common.....Luray, Va.
11. *Pseudanophthalmus engelhardti* Barber 1928—only 2 known English Cave, Tenn.
12. *Pseudanophthalmus barberi* Jeannel 1928—about 50 known..Rockhaven, Ky.
13. *Pseudanophthalmus grandis* n. sp. Valentine 1931—common Higginbotham's Caves, W. Va.
14. *Pseudanophthalmus lödingi* n. sp. Valentine 1931—10 known Shelta Cave, Ala.
15. *Pseudanophthalmus higginbothami* n. sp. Valentine 1931—common Higginbotham's Caves, W. Va.
16. *Pseudanophthalmus fuscus* n. sp. Valentine 1931—about 20 known Higginbotham's Caves, W. Va.
17. *Pseudanophthalmus subaequalis* n. sp. Valentine 1931—about 15 known Higginbotham's Caves, W. Va.
18. *Pseudanophthalmus humeralis* n. sp. Valentine 1931—only 5 known Monteagle, Tenn.
19. *Pseudanophthalmus robustus* n. sp. Valentine 1931—about 25 known Johnson's Cave, Tenn.
20. *Pseudanophthalmus hirsutus* n. sp. Valentine 1931—about 20 known King Solomon's Cave, Tenn.
21. *Pseudanophthalmus gracilis* n. sp. Valentine 1931—only 3 known Tommie's Cave, Va.
22. *Pseudanophthalmus pusio* (Packard 1888, Garman 1892? not Horn 1868)—a few samples collected but lost.....Carter Caves, Ky.

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[4] See J. M. Valentine, New cavernicole *Carabidae* of the subfamily *Trechinae* Jeannel, in this issue.

PLATE 23

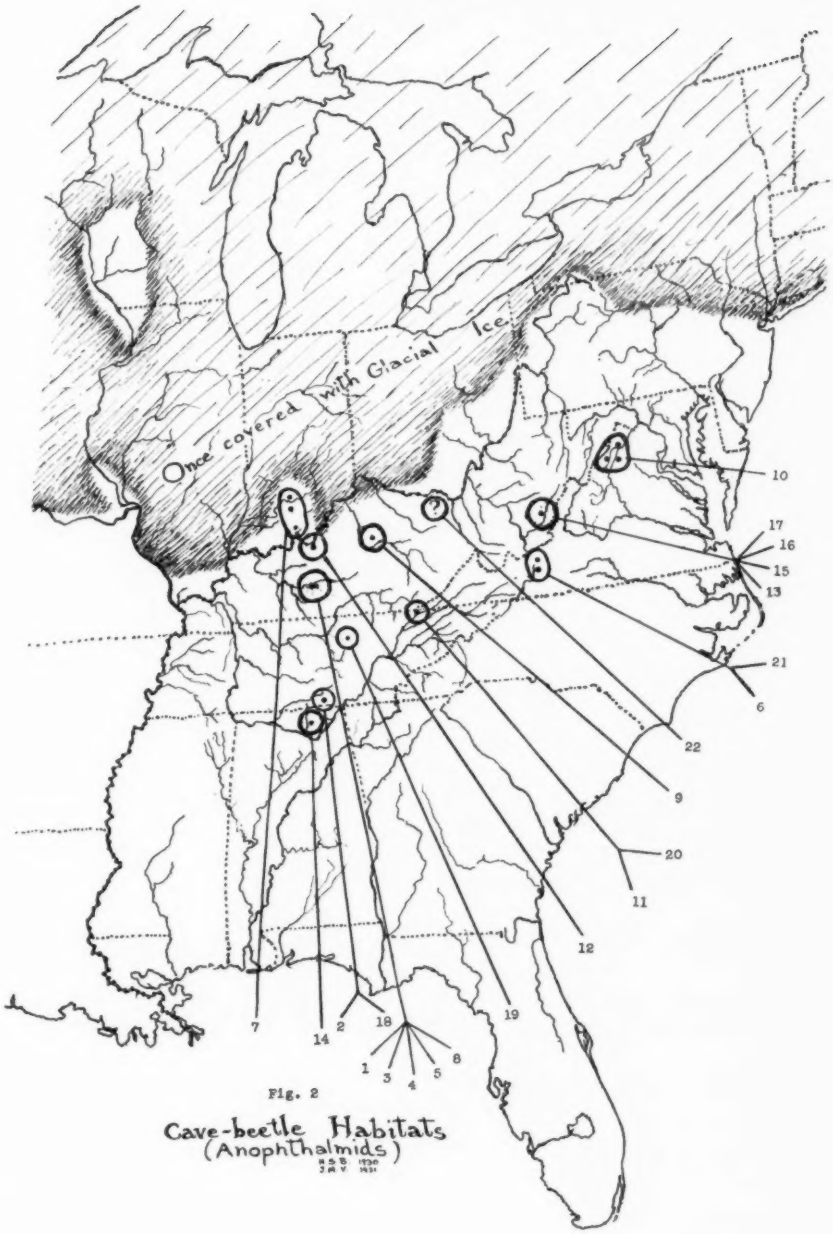

Fig. 2

Cave-beetle Habitats
(Anophthalmids)

GENETICS OF MOSSES

(An Abstract)

By H. L. Blomquist

The division of the plant kingdom known as the Bryophytes, or the Bryophyta, includes a large group of plants which contribute an important part to the world's vegetation. In view of their relative importance floristically, these plants have received little attention in several fields of botanical investigation compared with other plants. This is especially true in recent years and, of course, in those fields which are comparatively modern in their development. It is natural, therefore, that the systematics of this group should have received the most attention; but, with some few outstanding exceptions, especially in the past, this field has been developed to a large extent by amateur botanists Morphology comes next but with little work in recent times, although it has been replaced to a certain extent by cytology; while in the fields of ecology and physiology, these plants are seldom used. This lack of investigation in the mosses and liverworts has been especially true in the study of inheritance. This fact is perhaps in part due to the scarcity of well-defined varieties, the difficulties in technique, and no doubt to some extent to the minor position which these plants hold in the direct economic relations of plants to man. As genetic material, however, these plants are unique. The haploid generation is more highly differentiated than the diploid and is the independent and prominent one. Because of this fact, they furnish favorable material for genetic analyses since segregation, recombinations, interaction of factors, linkage, mutations, and the expression of genes or factors may be more easily observed and studied than in diploid material.

What was known about the genetics of mosses up to 1924 has been ably surveyed by Wettstein.[1] This account is divided into three parts: (1) The developmental histories and cytological facts which are of importance to the geneticist; (2) the pure genetic results and conclusions, such as, segregation and recombinations, gene and chromosome muta-

[1] Fritz von Wettstein. Genetische Untersuchungen au Moosen (Musci und Hepaticae). Bibliographia Genetica I: 1–38. 1924.

tions (polyploidy etc.); and (3) sexuality and its inheritance. In the second part of this paper the author deals briefly with results of his own investigations concerning the inheritance of mosses from crosses and regenerations. His methods, results and conclusions have, however, been more fully discussed in a more recent publication.[2]

It is the purpose of this paper to present in the form of an abstract the genetics of bryophytes (especially mosses) as set forth in the two publications mentioned above. This is done with the aim that this subject may be made more readily available to the average English speaking student who may not have access to these publications and who usually finds it laborious and time consuming to read the German language. It is done also with the hope that by knowing the facts, more interest will be aroused in further investigations within this fascinating field which Wettstein has so successfully opened up.

Developmental Histories

It must be realized that the alternation of generations in the mosses is strongly obligatory. This means that the gametophyte originally arises from a spore and that the sporophyte arises only from the fertilized egg. The gametophyte may reproduce itself directly by special broad bodies or in a great number of other ways by regeneration. Neither true apogamy nor parthenogenetic development has ever been observed in mosses. The sporophyte does not regenerate itself directly; if regeneration takes place from sporophyte tissue, which has been observed by several investigators, the result is a bivalent (diploid) gametophyte. The tendency to regenerate in the gametophyte varies in different mosses from cases in which every cell is able to regenerate to those which do not regenerate at all. The tendency to regenerate in the sporophyte also varies greatly in different mosses. Regeneration of gametophytes is important to a geneticist in that it is possible to reduce vegetatively a certain type to a one-celled stage and to reproduce a pure line from any stage in the moss development.

Cytology

The cytological investigations show nothing peculiar to this group in nuclear or cytoplasmic divisions, except that in some forms, especially the hepatics, the presence or absence of a centrosome is still a bone of

[2] Fritz von Wettstein, Morphologie und Physiologie des Formwechsels der Moose auf genetischer Grundlage. Bibliotheca Genetica X. 216 pp. 60 Textabbild. und 10 Tafeln. Leipzig, 1928.

contention. The archegonia normally produce one egg; two or more have been observed, especially in bivalent forms. One or more ventral canal cells may be present. The sperm is a worm-like cell composed mostly of nuclear material. If two eggs are present both are usually fertilized; fertilization of the ventral canal cell is known to occur. The union of the ventral-canal cell with the egg has been reported in *Sphagnum subsecundum*. Polyspermie has been observed in *Sphaerocarpus Donellii* in 8 per cent of cases. Whether they all function is uncertain.

Reduction division is difficult to observe but from what has been seen it appears to consist of two successive divisions as in the higher plants. In polyploid varieties abnormalities in reduction division are common. Reduction division and the division of the apical cell of protonema may be easily disturbed experimentally. By this method tetrads are prevented from breaking up in forms in which the spores normally separate (*Funaria*). The same result may be obtained in generic crosses. Combined tetrads are normally found in several forms, such as, *Sphaerocarpus, Fossombronia, Anthoceros,* etc. The chromosome number in the Bryophyta varies from 4 to 94 (polyploid) in the haploid phase. The counts are easiest to make in the antheridial cells and in reduction division. Heterochromosomes have been observed in two species of *Sphaerocarpus* (*S. Donellii* and *S. Texanus*) and seem to be of the XY type. The haploid number in mosses varies considerably. Six is the lowest number and has been found in a little less than one-fifth of the cases. Multiples of 6 (12 and 24), in about one-sixth of cases. Next to 6, 8 is fairly common as is also 10 and 20. In univalent forms 24 seems to be the highest number which has been observed in *Amblystegium riparium*. The number has been increased by repeated regeneration of gametophyte phases from the sporophyte.

In the hepaticae 4 is the lowest number while 8 seems to be the most common. In fact, a little over 77 per cent of cases investigated have 4 or 8 chromosomes, and 8 is the most prevalent. The highest number is 18.

SEX IN THE MOSSES

The following classification of types has been made, based upon the location of sex organs:

Monoecious: male and female on same individual
Hermaphroditic: male and female on same gametophore.
Synoecious: male and female within the same bracts.
Paroecious: male and female separated by a few bracts.

Autoecious: male and female on different branches of same gametophyte.
Heteroecious: autoecious and hermaphroditic on same plant.
Dioecious: male and female on different individuals.
Polyoecious: monoecious and dioecious forms in same species have been reported but should be confirmed. Under this category several forms are possible.

The proportion of types have been calculated for 915 European species and found to be, 54.6 per cent dioecious, 38.7 per cent monoecious (not hermaphroditic), 5.3 per cent hermaphroditic, and 1.4 per cent polygamous. This proportion has not been worked out for liverworts.

Sex organs are usually distinct. Rare cases have been reported of mixed archegonial and antheridial tissues in one organ, an indication that the two sex organs are homologous structures.

In recent years we have obtained strong evidence from a number of experiments that the *anlagen* for the development of both sex organs are potentialities of every cell whether the plant is monoecious or dioecious. The best proof for this theory is the occasional appearance of monoecious forms in such strongly dioecious genera as *Preisia* and *Marchantia*, and hermaphroditic plants in normally dioecious *Mnium hornum*. Both of these potentialities are not usually expressed in the same plant in dioecious species. The mechanism of reduction division determines which of the potentialities are to be expressed in such a way that in half of the spores produced the male potentiality is inhibited and in the other the female. This has been shown in spore germinations by the Marchals to be true in a dioecious moss, in *Fegatella* by Blakeslee, and in *Sphaerocarpus* by several investigators. In fertilization the two sex tendencies are combined and each cell of the sporophyte is, therefore, bisexual. This has been confirmed in experiments by the Marchals and others who have regenerated bivalent (diploid) gametophytes which proved to be monoecious while the univalent ones were dioecious. In some cases (*Amblystegium*) no sporophytes were produced while in others (*Splachnum* and *Bryum caespiticum*) bivalent (tetraploid) sporophytes were formed from fertilization in bivalent gametophytes. Irregularities, however, often occur in bivalent gametophytes in which only one sex organ is produced due probably to irregularities set up in reduction division in many polyploid forms.

The next question which arises is, in monoecious mosses, where does the separation of sexes take place? This is evidently a different matter from that discussed above which has to do with the genotype while in the latter we are concerned with the phenotype. It apparently be-

longs to the same class of expressions which obtains in the development of a hermaphroditic flower which we are equally unable to understand. Correns has shown that if cells from either sex organ in a monoecious moss is regenerated it produces a monoecious plant like the parent. Correlation probably obtains here as it has been shown to obtain between sexually different branches in autoecious forms like *Funaria*. If the male shoot is removed early, the female branch which normally gives rise to archegonia, develops antheridia instead or in rare cases, at least, becomes hermaphroditic.

Experiments have been carried out to show that sex tendencies are to a certain extent quantitative. In *Bryum caespiticum* the male plants "blossom" first. This tendency is shown also in hermaphroditic bivalent forms in which antheridia appear before the archegonia. The proportion of archegonia to antheridia is 1:4.98. If a bivalent female plant, which has been produced directly from a univalent protonema, is crossed with a univalent male, the archegonial tendency is strengthened and the proportion becomes 1:1.37.

In certain species of *Dicranum*, *Macromitrium*, and others dwarf males have been found. These are usually epiphytic upon the female plants, a situation which needs further investigation.

REGENERATION OF POLYPLOID VARIETIES

Stahl (1876) is apparently the first one to have regenerated sporophyte tissue. Since then, similar experiments have been repeated by several investigators. The result is a bivalent (diploid) gametophyte. In a few cases these have been fertile and produced bivalent (tetraploid) sporophytes. The author also succeeded in producing polyploid forms directly from univalent protonema by the use of low temperature, chloralhydrate, or hypertonic solutions. This same method was used with similar results when applied to the capsule at time of reduction division. The difference between univalent and bivalent plants is usually indicated morphologically by larger cells, a greater number of cells, and consequently larger organs. This does not hold, however, in all bivalent forms and for higher valencies the cells are generally smaller, fewer in number, and the leaves especially become wrinkled and often split due to irregularities in growth. In cases where tetraploid sporophytes have been produced by repeated regeneration, further regeneration may be produced but the development ceases in the protonema stage. The author found, however, that in hybrid mosses regeneration is more successful and higher valencies (octaploid) may be produced than when using one

line or individuals from one species. Also trivalent combinations have been produced from three different genera, e.g., *Physcomitrella* X *Funaria* X *Physcomitrium eurystomum*. It will be interesting to see if these combinations will further the extent of building up higher valencies. Also triploid sporophytes with two *Funaria* and one *Physcomitrella* chromosome sets have been produced which showed strong *Funaria* characteristics.

According to some investigators (the Marchals), reduction division takes place in bivalent forms regularly by double pairing of homologous chromosomes. The author finds, however, that this is not usually the case but that reduction division is very irregular; some spores are bivalent, but many have different numbers. In some cases abnormally large spores (polyvalent) are produced while others are sterile. In such forms a large number of chromosome mutants arise in which the effects of different chromosome compositions may be clearly seen as has been done in *Solanum* and *Datura*. Often in bivalent and monstrous (polyvalent) forms vegetative reproduction is also irregular and forms with a reduced number of chromosomes to normal univalent individuals arise.

GENETIC INVESTIGATIONS

Bayerhoffer (1849) was apparently the first one to point out the probability that hybrids occur in nature. The parents in his case were supposed to have been *Physcomitrium pyriforme* X *Funaria hygrometrica*. Since then about twenty-four plants have been reported as hybrids based, of course, upon purely systematic evidence. Among liverworts no natural hybrids have been found. The moss families in which hybrids have been most often reported are, *Funariaceae*, *Orthotrichaceae*, and *Ditrichaceae*. The others are few and scattered among various families.

The first successful artificial cross in mosses was carried out by the author in 1923 in the Funariceae. During the same year Schweitzer succeeded in crossing haploid and diploid plants of *Splachnum sphaericum* producing triploid sporophytes. Since then a great number of crossing experiments in mosses have been carried out by the author which have led to some interesting conclusions.

VARIETAL CROSSES

The only moss which has given rise to several distinct varieties is *Funaria hygrometrica* (L.) Sibth. These varieties crossed readily whichever way the cross was made. Some characters considered were:

spore size, rapidity of division of first protonema cell, width of leaves, form of paraphyses, capsule form and capsule color. The F_1 sporophyte was in general intermediate between the two parents. The gametophytes segregated into the expected Mendelian ratio of 1:1. The best proof for this was where tetrads remained combined. In such cases two plants from each tetrad carried one or the other allelomorph. When the second division was prevented from completion, two bivalent spores were produced which developed into two perfectly segregated gametophytes. If segregation took place in the second division, two identical hybrids would have been formed. There was some recombination, but spore size and the rapidity of division of the first protonema cell, and width of leaves and form of capsule were found to be completely linked. In these experiments a gene mutant arose which differed from the other varieties in several characters. With the help of Marchal's method of regenerating sporophyte tissue, bivalent gametophytes of *Funaria hygrometrica* were produced. These were crossed with each other and also with univalent forms to form triploid and tetraploid sporophytes. By these experiments the quantitative effect of increased factors in doubled over single allelomorphs was expressed in increased dominance. The same method was used in the study of certain characters in *Physcomitrium* and is called *homogenomatic heteroploidy*.

SPECIES CROSSES

Two species of *Funaria* (*F. hygrometrica* and *F. mediterranea*) were successfully crossed. The sporophyte resembled strongly the sporophyte of the maternal parent whichever way the cross was made. Segregation of gametophyte characters was extremely complex in F_1; a great number of different forms arose which differed more or less in all organs. The important fact, however, was that pure maternal types segregated out but no pure paternal, although some approached the latter fairly closely. In reciprocal crosses the same results were obtained, i.e., pure maternal types would appear but no typical paternal types. This fact led him to formulate the theory that pure paternal types did not appear because of the effect of the maternal cytoplasm upon the expression of the factors contributed by the male parent. This meant that if the gene complex in a spore happened to be composed exclusively of genes contributed by the male the plant which developed from it would resemble the paternal plant very strongly but not exactly. To prove this theory he crossed the F_1 plants which most closely resembled the paternal type with the original paternal type. The results were differ-

ent, depending upon which way the cross was made. If the F_1 plant was used as male, the result was pure paternal types; if it was used as female, the offspring were identical with it. Similar crosses made between the pure F_1 maternal types and the original maternal types always gave pure maternal types. These results he presents as conclusive evidence that his theory stated above was correct.

GENERIC AND SUBFAMILY CROSSES

Several generic and sub-family crosses were also made within the family Funariaceae. In most of the crosses in which *Funaria hygrometrica* was used, successful crosses could rarely be made except where *F. hygrometrica* was used as male. In other generic crosses reciprocal crosses were about equally successful. Most of these crosses were highly sterile. The spores were formed but were shrivelled and remained in tetrads. The following were the most important crosses made:

Physcomitrella patens X *Funaria hygrometrica*
Physcomitrella patens X *Physcomitrium eurystomum*
Physcomitrium eurystomum X *Physcomitrella patens*
Physcomitrium eurystomum X *Funaria hygrometrica*
Physcomitrium eurystomum X *Physcomitrium pyriforme*
Physcomitrium pyriforme X *Physcomitrium eurystomum*
Physcomitrium pyriforme X *Funaria hygrometrica.*

Only from the fourth and the last cross could a considerable number of offspring be analysed. Among the segregates some pure maternal types appeared together with a number of intermediates between the two parents with more or less paternal characteristics but no one purely paternal. This he concludes is a strong support to his theory of the interaction of genes and cytoplasm. In fact, in these crosses no purely paternal types could be brought out by crosses of F_1 plants with original paternal types as in species crosses. This indicates that in these crosses the paternal gene complex alone is not able to express itself in the maternal cytoplasm and the result is that all such combinations are sterile. Reduction division was more or less irregular and often gave rise to abnormally large spores with probably more than a haploid number of chromosomes. Such spores would then give rise to polyploid individuals among which a few showed strong paternal characteristics. The supposition is that in such cases a complete maternal haploid set is present together with a larger number of paternal chromosomes. Under

such a condition the paternal chromosomes express themselves and may be dominant over the maternal ones. Also in such crosses as *Physcomitrella patens* × *Physcomitrium eurystomum* and reciprocal cross, now and then, pure maternal plants would appear but never paternal. In the cross *Physcomitrium* × *Physcomitrella*, tetrads stayed together and could be analyzed. In one case one half of the spores developed into maternal plants while the other two developed into paternal which died in the early stages of development. This goes to show that for these two genera not only the two nuclei are different but cytoplasm as well. The sporophytes in all cases resembled the maternal parent whichever way the cross was made. In these cases the sporophytes could be made to regenerate bivalent races of different genera. Such polyploid races behaved the same as did such races of *Funaria* mentioned above. Especially striking were the quantitative effect of triploid sporophytes of *Physcomitrella bivalens* × *Funaria univalens* and *Physcomitrella univalens* × *Funaria bivalens*.

The author calls attention to the important fact that one chromosome set alone in a plasm of another species is not viable as shown by the absence of paternal types in crosses, while even in a double amount it is viable provided at least one set of chromosomes (maternal) is present in its own cytoplasm. It would seem, therefore, that there must be two nuclear effects, (1) those which are specific upon its own plasma and apparently necessary for the ordinary life processes and (2) those which under certain conditions express themselves in a foreign plasma, but which affect only the details of morphological development.

DUKE UNIVERSITY,
DURHAM, N. C.

JOURNAL

OF THE

Elisha Mitchell Scientific Society

VOLUME 46
1930–1931

Published for the Society
by the
University of North Carolina Press

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